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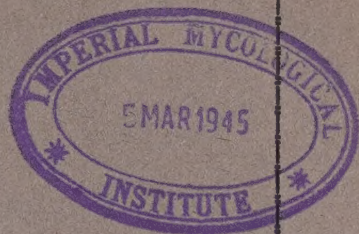
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CONTENTS

Economic Factors Preventing Change in Agriculture with Special Reference to Wheat Growing.....	by A. M. Ramsay	141
Rural Reconstruction Commission.....	Summary of the Second Report	148
Selection of Suitable Areas for Settlement of Returned Men.....	by Sheila Rowley	152
Factors Affecting the Efficient Production of Supplementary Pasturage and Fodder under Partial Irrigation.....	by W. M. Willoughby	157
Climatic Aspects of the Bradfield Scheme.....	By Ann Marshall	165
Scientific Method.....	by H. C. Trumble	169
Technical Notes—		
The Resolving Power of the Eye and the Classing of Wool.....	by W. R. Lang	175
Production of Copper Deficiency Symptoms of Citrus in Solution Culture.....	by G. C. Wade	176
Australian Institute of Agricultural Science—		
Seventh General Meeting.....		178
Meeting of Council.....		179
Meetings of Branches.....		179
Current Notes and News.....		182
Correspondence		185
Book Reviews		187
Personal Notes.....		188

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DECEMBER, 1944

Economic Factors Preventing Change in Agriculture with Special Reference to Wheat Growing*

By

A. M. RAMSAY, B.Ec.

It seems to be universally acknowledged that agriculture and agriculturists tend to be conservative ; that change in agriculture comes more slowly and less frequently than in other industries. This article is concerned with showing why certain changes in agriculture are at once vital and yet for the individual farmer are difficult if not impossible.

Changing economic conditions (including those due to war) call for alteration in one or more of the following :

- (1) The composition of the farm products.
- (2) The technique of farming.
- (3) The size of the farm.

The Composition of the Farm Products and the Technique of Farming.

Several causes may operate to make it desirable to change the kind of product obtained from a particular piece of land and/or the methods used in obtaining any one of them even if these crops and methods were right in the first place. Some such causes may be listed.

- (1) Change in relative profitability of products due to
 - (a) increased yield through a changing technique, for example, better manurial knowledge ;
 - (b) change in relative demand, for example, increase in demand for dairy products as against cereals.
- (2) The marginal social net product may not be equal to the marginal private net product, for example, a method of growing a crop may be profitable to the individual and may continue to be profitable to him as long as he intends staying on the land, yet in the long run might cause irreparable damage.

* A paper read to the South Australian Branch of the Aust. Inst. Agric. Sci. A slightly different approach to the problem, using some of the statistical material, has been published by Professor K. S. Isles and the author.⁽¹⁾

In this case the marginal private net product is greater than the marginal social net product.

Now each of these indications that change is necessary manifest themselves in fairly distinct ways, although one of them, at once the most dramatic and far-reaching of them all—soil erosion—has most often been overlooked by the farmer. However, many farmers are now becoming painfully aware of the problem and certainly it is not unknown to those responsible for agricultural policy. If, then, these symptoms that change is desirable are fairly obvious, deep causes must be at work to prevent their being heeded.

The answer to the unresponsiveness of agriculture to cause of changes lies in the composition and nature of farm costs. It is accepted by authorities on agricultural economics that a high proportion of farm costs are fixed costs, and that these costs remain fixed over a long period. The biggest item in these fixed costs is, of course, interest on the money, usually borrowed, which is invested in the enterprise. The rest of this article is concerned with the effect of this fixed cost on agriculture.

A farmer's fixed costs are determined when he borrows capital, that is, often, when he buys his land. Therefore a farmer has a high proportion of fixed costs that would only be appropriate for

- (1) a certain technique of farming,
- (2) a particular composition of products,
- (3) a particular price relation,
- (4) a particular level of fertility.

Thus we can find farmers with fixed costs appropriate to a two-year rotation, a complete reliance on wheat, agricultural methods that presume virgin country and outlays as if the cereal were 6s. a bushel. Naturally each and every one of the factors listed above change, thus the level of fixed costs is no longer appropriate.

It might be that the changing factor is soil condition and that, because the land has been worked on a two-year rotation, its soil fertility and structure have been impaired and erosion is taking place. However, the land may have been taken up and the initial debt incurred when it was considered that a narrow rotation of crops was desirable and possible. The farmer is then faced with the choice of continuing his old methods in an attempt to meet his costs and slowly but surely spoiling his land, or not meeting his costs and facing the consequences. In this case the farmer's choice is so important that the State cannot allow it to be wrong; it cannot allow permanent wastage of its chief asset by erosion. It is assumed that a narrow, soil-depleting rotation of crops is a major cause of soil erosion.

So far it has been argued that because a high proportion of costs are fixed, and because these costs become inappropriate a certain situation arises. The assumptions may be shifted a little in order to reveal a new problem and assume that the farmer bought his land on the very best advice available and thus his fixed costs are appropriate to normal conditions. Though the absolute level of his costs may be correct from the long-period point of view, yet, because a high proportion of his costs are fixed, it is unlikely that the farmer can carry this load in times of slump. In more technical language the farmer is not in a sufficiently strong financial position to assume the entrepreneurial functions dependent, for example, on changes in world prices.

This section of the argument is based on the assumption that the land was bought on a real knowledge of normal values; in so far as land values are inflated to that extent the problem is aggravated; and land values are usually inflated, because more land transfers take place during booms than depressions. High prices breed false optimism and land is bought at inflated values; during a depression farmers cling tenaciously to their land because it represents their capital, home, and way of life.

Change in the Size of the Farm.

Changes in the technique of farming a particular crop or a change in the composition of the farm's products cause a consequent change in the optimum size of the farm. Thus if, for example, it is desirable and obvious, because of any of the conditions mentioned above, that wheat farming on a narrow rotation should give place to a wide rotation combined with sown pastures, the optimum size of the farm is likely to increase. If, to continue the same example, the cause demanding change is soil erosion, then that change must come quickly; smaller farms must be amalgamated into larger ones. Once again, the individual farmer is, as a rule, powerless to make the change. Some are rich enough to buy out their neighbours, but generally each clings on to his farm and not until one goes bankrupt has another an opportunity of obtaining a larger area at a price which does not overburden him with fixed costs. Meanwhile, the land concerned has been rendered equally bankrupt. This conclusion, that the method of *laissez-faire* elimination of the weak or unwanted business unit cannot be safely used in agriculture, is of particular importance. Once more the State cannot afford to wait until the soil has been exploited for the change in the optimum size of the farm unit to be made.

Problem of Working Capital.

It might be argued that if a change is desirable from, say, wheat to pasture, then, since the pasture will in the long run pay better than wheat, the fixed costs can be more easily met. This, however, is to miss one of the difficulties of the situation: *the farmer is frequently in no position to reap long-period rewards.*

A wheat farmer, for example, may realize that it is desirable to change to a wide cereal rotation with a sown pasture. But each acre that is taken out of crop and sown down to pasture earns little or no income for one, or even two, seasons. And if each acre carries a high debt burden the farmer cannot afford the change-over; he cannot forego the income on each and every acre he puts down to pasture.

However, even if the farmer has no fixed charges to pay on his land and equipment, and thus is in a position to forego income on his land to sow pastures, he still has to be able to borrow or provide enough working capital to buy a flock or a herd as well as any new capital equipment that goes with his new enterprise, and keep himself and his family in the meantime. It follows, then, that the farmer, unless he is in a better position than most, cannot make the desirable change or reap the long-period rewards. In other words, the farmer cannot bear the risk involved in an industry where the forces making for change are strong, and the consequences of resisting them drastic. Other shoulders must assume some of the entrepreneurial risks if our agriculture is to be flexible, yet stable, and our soil preserved.

In part of the foregoing the assumption was held that the farmer knew the right course to pursue, the right rotation of crops or the right price at which to buy new land, but was prevented from taking this course by high fixed costs and capital starvation. In practice, of course, in Australia at any rate, the farmer often does not know the right course of action, and that makes it more than ever certain that the wrong course will be pursued and all the problems raised further aggravated. If financial, and other reforms, are undertaken to solve the problem of fixed costs, if artificial land values are prevented, and if the State assumes some of the entrepreneurial risks, it still remains that facilities must be provided to collect data and organize research so that both the State and individual will have adequate knowledge on which to base decisions. It follows that the neglect of agricultural economics in Australian universities and the lack of adequate government encouragement of the same subject are among the factors which have to be overcome if Australian agriculture is to become more flexible.

Statistical Evidence.

Probably the best agricultural land in South Australia is in the so-called inter-mountain valleys of the Flinders-Mt. Lofty horst which runs roughly north and south and parallel with the Gulfs. County Victoria, which was selected by the Soils Division of the Council for Scientific and Industrial Research for a survey,

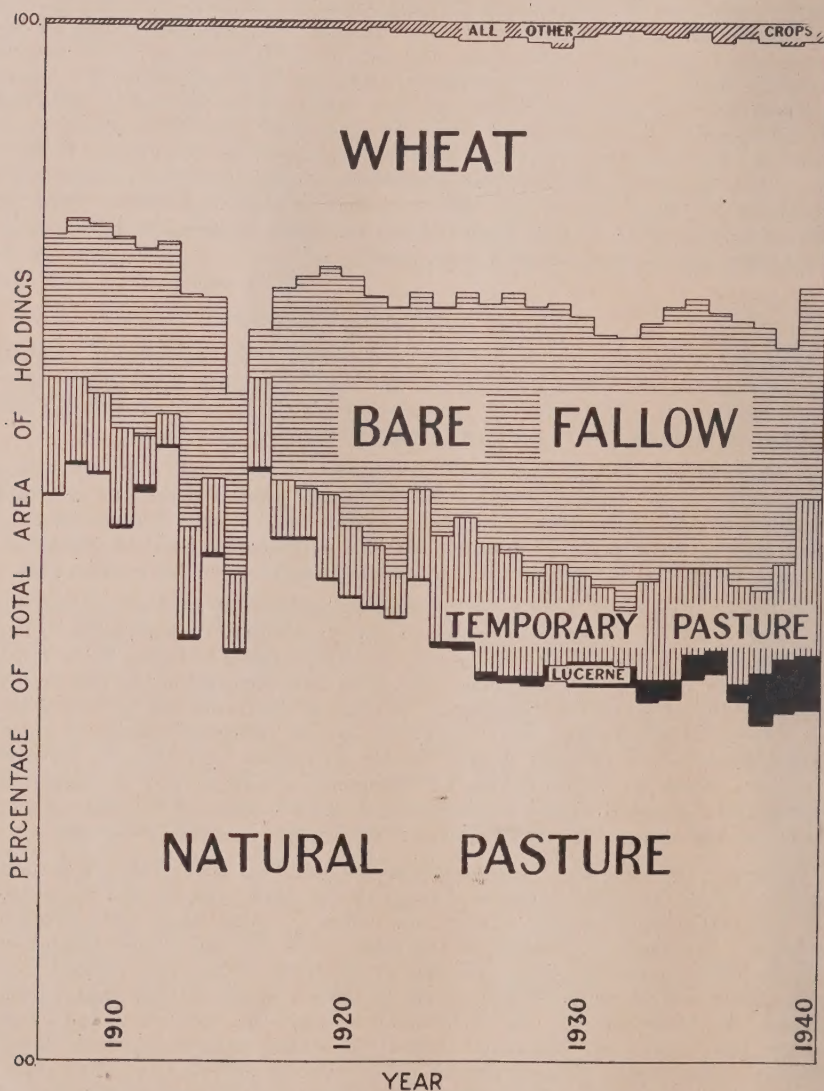


Figure 1.

Land Use in the Hundred of Belalie, South Australia, 1907 to 1940.

[Block by courtesy of J. Dept. Agric. S. Aust. Graph by R. I. Herriot, Soil Conservator, Dept. Agric. S. Aust.]

runs athwart this upland. The Hundred of Belalie, in this County, is the area from which data are drawn. This Hundred centres around Jamestown, some 140 miles north of Adelaide, and is representative of the State's best wheat lands, although because of its structure there are stony ridges. The rainfall, 17 to 18 inches, is well placed during the growing period and what summer rain does fall is valuable for lucerne growth. The area was first cut up into farms in 1870, although until 1910 sheep stations were being subdivided.

The land use in the Hundred of Belalie is best explained by referring to Figure 1. From this figure the following facts can be seen :

- (1) The predominance of wheat grown over all other forms of land use.
- (2) The insignificance of other crops such as oats and barley.
- (3) The small proportion of land left out to temporary pasture for soil-building purposes.
- (4) The gradual encroachment of agricultural land upon natural pasture.
- (5) The increase in the area sown to lucerne in recent years.
- (6) The large amount of land each year left completely bare and thus vulnerable to the forces of erosion.

The main tentative conclusions reached so far may now be listed :

- (1) Agriculture tends to respond dangerously slowly to causes of change because a high proportion of farm costs are fixed costs.
- (2) Even if fixed costs are appropriate in the long period, most farmers are not in a financial position to reap long-period rewards.
- (3) Costs of change, both in income foregone and actual outlay, are too high for individual shoulders.
- (4) Each of the above problems is aggravated by inflated prices for farm land and ignorance.

Two investigations to test the validity of these conclusions have been made, and although neither has been carried far enough to stand full statistical analysis some results are worth stating as illustrating the theoretical case.

In July, 1942, the Hundred of Belalie was visited by Professor K. S. Isles, Professor of Economics in the University of Adelaide, and the author. A questionnaire relating to production activities and costs was completed for 31 farms ; subsequent official duties prevented widening the sample. A summary of some of the data from these questionnaires is set out in Table 1. Although the figures are not conclusive, the following tendencies can be seen :

- (1) The farmer carrying the highest fixed overhead costs per acre usually had the highest proportion sown to wheat, the " traditional " crop of the district.
- (2) The farms with the lower fixed overhead costs per acre had responded to the causes of change much more readily than those with higher.

There is no wholly satisfactory objective measure of change in the composition of production, but the best single increase of the type of change which was desirable was taken to be the absolute increase (positive or negative) in leyland and lucerne acreages combined as a percentage of the total farm.

A comparison of the overhead expenses per acre and the index of change supports the statement that only those farmers with relatively unencumbered land can respond to change. More detailed tables of land use underlining the above conclusions have been published previously.⁽¹⁾

One of the most important causes demanding change in agriculture is soil erosion, and yet, because some farmers are unaware of the extent or seriousness of the damage done or being done to their land by erosion, data collected by interviews with farmers are not very satisfactory. Therefore a second approach was made to test if financial considerations were, by preventing change, a basic cause of erosion.

TABLE I.

Land Use (1939-40 and 1941-42) in Relation to Annual Overhead Expenses^(a) on 31 Farms in the Hundred of Belalie, South Australia.

Farm No.	Annual Overhead Expenses per Acre.	Percentage of Total Farm Devoted to Wheat and Other Cereals. ^(b)		Index of Change. ^(f)	Farm No.	Annual Overhead Expenses per Acre.	Percentage of Total Farm Devoted to Wheat and Other Cereals. ^(b)		Index of Change. ^(f)
		1939-40.	1941-42.				1939-40.	1941-42.	
	<i>s. d.</i>					<i>s. d.</i>			
1	9 0	—	—	0	17	3 7	28	19	+8
2	8 6	52	52	0	18	3 5	45	31	+34
3	7 6	42	42	0	19	2 9	11	7	+16
4	7 4	51	51	0	20	2 8	20	33	+7
5	6 6	46	46	0	21	2 2	46	34	+11
6(c)	6 4	(c)	67	(c)	22	1 9	17	12	+14
7	6 3	24	24	0	23	1 7	17	13	-2
8	6 2	46	31	+31	24	0 7	16	16	0
9	5 11	30	30	0	25	(e)	26	26	+2
10	5 6	48	48	0	26	(e)	16	16	0
11	5 6(d)	29	29	0	27	(e)	31	31	0
12	5 0	32	26	+32	28	(e)	20	45	-12
13	5 0	35	17	+27	29	(e)	37	29	+26
14	4 5	31	33	+1	30	(e)	14	0	+14
15	4 3	6	6	+1	31	(e)	31	0	+56
16	3 7	42	37	+13					

(a) Adapted from Table II, Isles and Ramsay.⁽¹⁾

(b) "Other cereals" in most cases insignificant.

(c) Full possession after 1939-40.

(d) Estimated.

(e) Owned without encumbrance.

(f) Absolute increase (positive or negative) in temporary natural pasture and lucerne acreages combined, as a percentage of the total farm.

The Soil Conservator of the South Australian Department of Agriculture (Mr. R. I. Herriot) had inspected all the farms in the Hundred of Belalie. He was asked to supply two groups of farms, Group I with erosion evident (mainly worked on a narrow rotation), Group II with land in better condition (worked in the main on a wide rotation). A search was made of the title deeds of the land in each group in order to ascertain if the registered mortgages and other encumbrances were significantly different in each group. It was found that on the eroded farms the mortgage interest was high, the land had changed hands since 1920 more frequently, and very little land had been acquired by inheritance. In fact the land in best condition had usually been inherited without encumbrance.⁽¹⁾

During the completion of questionnaires and the search of title deeds many land transfers were recorded, the number recorded for each year set against wheat prices showed that far more land changed hands during the booms in agricultural prices than during the slumps.⁽¹⁾ Since, then, it is the debts contracted during high prices that are perpetuated, the whole problem of fixed costs, bad enough if long-period costs be appropriate, is aggravated.

Without pushing either set of evidence too far, the facts do bear out the statements that high fixed capital charges are positively linked with soil erosion by way of land use and that the same charges prevent response to causes making for change, even if the penalty for not responding be very high.

Conclusions and Recommendations.

Each of the problems discussed, for which some proof was offered, are now taken in turn and measures suggested to overcome the factors preventing desirable change.

The Problem of Fixed Costs.

It is necessary that a greater proportion of farm costs should be variable costs, that is, costs which vary with returns. Since by far and away the most important part of fixed costs is rent or interest, the suggestion comes down to making the rate

of interest vary with farm profitability. At the moment the farmer pays rent or interest at a constant figure, come drought or low prices. From this position it is necessary to pass to one where the farm enterprise is looked on more as a partnership; the provider of capital and the provider of labour and enterprise-sharing profits and not one of them taking a fixed slice. It might be that this is only practicable where the State is the landowner, or the banker.

The Problem of Fixed Costs being Too High.

As stated, not only is the proportion of fixed costs too high, but inflated land values cause the costs to be inappropriate.

To remedy this, land transfers at values that are above the long-period yield value, as determined on the best expert advice, must be prevented. Short of land nationalization, this could be done by the State refusing to register transfers showing purchase prices beyond a determined yield value. The National Security Regulations are having this effect although in one district at least which was visited recently the spectre of inflated values seems to be appearing.

The Financing of a Change-over.

It was found that frequently the farmer was unable to finance desirable changes for several reasons:

- (1) He had to forego income on each acre for a season if, for example, he wanted to change from wheat to good sown pasture.
- (2) He would need working capital in order to
 - (a) stock his new enterprise,
 - (b) keep his family during the change-over period.

The necessity to forego income in order to change is at once the most important and least recognized of the problems. If an agricultural change is reckoned necessary on the best expert advice, then the farmer should be allowed to forego fixed capital expenses on each and every acre on which he undertakes the change. Thus if the State were his landlord it should cancel his rent on the particular acres for the appropriate period. Private mortgages would have to be taken over by the State (a really far-reaching use for the new Mortgage Bank) or the interest financed from the Central Bank during the change-over.

The second and third problems listed above, the provision of working capital for the change-over, should be carried by such an institution as the Mortgage Bank at very low rates of interest.

The schemes outlined above transfer some of the risks of farming from the farmer to the State; the entrepreneurial function of, for example, interpreting or of withstanding the financial difficulties of changing from a fertility-depleting to a fertility-conserving agriculture would no longer be performed by the farmer. It is surely desirable that the farmer should not bear such risks. However, if the State assumes these risks it does not reduce the farmer to the status of a hired servant, since the entrepreneurial functions of farming technique would remain. It must be stressed, though, that if the State assumes some risks it can reasonably assume some control over the methods used on the farm. Although farmers are usually painted as individualists who will brook no interference, quite a few have admitted that they would readily lose some of their so-called independence in return for more security. Most farmers now realize that their pre-war independence was not very real.

It is evident that for each of the solutions suggested above (for example, correct assessment of land values) far more knowledge would be required of agricultural economics in general, and farm costs in particular, than we now possess. It would seem essential that active steps be taken to obtain farm costs; the best solution has probably been put forward by Perkins (Proc. Aust. Assoc. Adv. Sci., 1933). Looked

at more broadly, the problem of having an agriculture flexible enough to make changes, and producing the most desirable crops and products by methods that preserve the land, cannot be achieved without new measures—financial, as well as scientific and educational.

Reference.

1. Isles, K. S., and Ramsay, A. M.: *Econ. Rec.*, No. 38, June, 1944.

(Received for publication, 16th November, 1944.)

Rural Reconstruction Commission

A SUMMARY OF THE SECOND REPORT.

The Second Report of the Commission discusses in detail the settlement and employment of returned men on the land ; in doing so an examination is made of the settlement following the war of 1914-18 and the lessons to be learnt therefrom. There is also the draft bill of the Returned Sailors, Soldiers and Airmen's Imperial League of Australia on the subject, together with details of the Commission's plans for soldier settlement.

Chapter 1.—A Brief Review of Soldier Settlement after the War of 1914-1918.

During the period 1902-1914 agricultural development generally had been satisfactory and, with steadily rising prices and the expansion of many types of farming, land settlement presented superficially, at least, a very suitable method of providing for returned men. In every State, schemes were developed, and although some attempt was made to ensure that only qualified men were assisted on to the land, the standard accepted for qualification was often very low. The attempt to stimulate a very rapid land settlement led to wholesale over-capitalization of stock and farming equipment and many of the settlers went through the developmental stages without much thought of the costs. Later, as interest had to be met, and the sharp fall in the prices of agricultural products occurred, many left their holdings, although the majority did their best to carry on. The proportion of returned men finding themselves in financial trouble was very high and the sums the States had to find became larger than anticipated. To make matters worse, the Agricultural Departments could give very little in the way of advisory service and the demand for concessions and artificial increments became more and more insistent.

Commonwealth and State relations over soldier settlement were matters for constant discussion. In 1916, the Premiers' Conference had passed a resolution by which the Commonwealth and States were to bear equally the cost of the difference between special soldier concession rates (during the early years of occupancy) and the cost of the monies raised by the States. The Commonwealth had also undertaken to lend money to the States up to £625 per settler (subsequently raised to £1,000) for the settlement schemes. When the State losses became larger than anticipated some argument ensued as to the financial responsibility, which the Commonwealth had undertaken, and in 1927 Mr. Justice Pike was appointed a Royal Commissioner to enquire into this matter and the question of losses. He found that the Commonwealth should bear half the losses sustained by the States in the schemes and that the gross loss at 1st July, 1927, was approximately £23,500,000. A State-by-State analysis of the losses is given in an appendix to the Report. The outstanding feature of the Commonwealth-State relations was that, although the States sought to make

the Commonwealth a partner in all losses, the Commonwealth had no means of protecting itself under schemes which were devised by the States and jealously guarded by them as being their sole prerogative.

Investigations were made by State committees on the adjustment of farm areas, but the collapse of prices during the depression hopelessly invalidated the conclusions.

The Commission received evidence that the £23,500,000 loss in 1927 had grown to about £45,000,000 in 1943, representing about £6 5s. per head of the Australian population, or £1,200 for each serviceman originally settled (and this sum does not include private and merchants' losses). Although the proportion of failures was high, the losses must not be construed as a reflection on soldiers as settlers when compared with any other type.

Land for the settlement schemes was obtained in three ways :

- (a) By the subdivision of Crown lands ;
- (b) By the subdivision of purchased estates ; and
- (c) By the purchase of individual farms.

Under (a) it is pointed out that much of the Crown land was difficult to settle owing to it being the " left-over " after previous farmers had made their selections, was marginal country, or was on heavily timbered country difficult to clear. The subdivision of larger estates met with varied success and initial over-capitalization of the land was only increased by the capital spent on equipping the farms as small-scale units. The purchase of individual farms was usually disastrous financially.

Chapter 2. —Discussion of the Present Problem Including Reference to Lessons of the Past.

The Commission is of the opinion that expansion of production requirements will most likely follow two trends, viz., the short-term in the immediate post-war years to meet world food shortages, and the long-term, based on prospects of international trade and national nutrition policies, and prospects of a continuous increase in the Australian population. During the short-term trend the emphasis should be more on additional farm labour than on new settlement, which would come later. The forestry employment outlook will depend to a large extent on national development policy ; it will be referred to more fully in the Commission's report on forestry.

Estimation of the number of servicemen who will want to go on the land is most difficult. Approximately 9 per cent. of the first A.I.F. settled on the land and, on that basis, about 54,000 will have to be considered after this war. However, the percentage may not be as great this time, for the following reasons :

- (a) Comparative lack of enthusiasm for the land prior to this war, compared with that prior to 1914-1918.
- (b) The history of previous settlement projects should prompt a more cautious outlook.
- (c) There are no vast areas of Crown land to be opened.
- (d) There are many more well-developed secondary industries now than in 1918.
- (e) Many farmers and rural workers have already gone back to food production and may have permanently re-established themselves before hostilities cease.

Evidence placed before the Commission has laid emphasis on the extent of failure of past soldier settlement due to inexperience and general unsuitability of a large number of assisted men ; Justice Pike came to the same conclusion. A contributory factor of many failures was the policy of pushing men forward to farm ownership long before they were fitted for the responsibilities. After this war, it

will be expected that there will be a strong demand by young servicemen to own farms as a means of acquiring homes and that many other considerations will be overlooked. Such a pressure will have to be resisted to the extent that inexperienced and unsuitable men do not attain the status of farm owners. The emphasis should be on qualifications, not desires as such, in determining the serviceman's place in farm life.

Provided the qualifications of experience and capacity are satisfactory, lack of capital should not be a bar and the disability should be overcome mainly by concessions on interest, to operate until financial stability is reached. Inflation of land values will have to be guarded against and, since suitable Crown lands are already very limited, provision will have to be made to acquire compulsorily land for soldier settlement. Unsuitable areas and inadequate farm size were often contributory causes of failure after 1918; another serious fault was the lack of guidance and supervision of settlers, both from the technical and financial viewpoints.

Chapter 3.—The Proposals by the Returned Sailors, Soldiers and Airmen's League of Australia.

The League gave considerable assistance to the Commission and even went so far as to present a draft bill embodying the principles it advocated and containing many valuable suggestions. The Commission was in agreement with the League on most of the main principles.

Chapter 4.—Basic Organization and Division of Responsibilities between the Commonwealth and the States.

The Commission is of the opinion that the greater part of the financial responsibility must be accepted by the Commonwealth Government, which must also decide which plans for settlement are to be adopted. Close collaboration with the States (in the form of an agreement) is necessary since under the Constitution they have control of the land and land utilization. It is suggested that the States should have soldier-settlement authorities to formulate and submit schemes, whilst there should be a Commonwealth investigating body to report on these and a financing body to handle the money.

Chapter 5.—The Commission's Plans for Farm Employment and Land Settlement for Returned Men.

The selection of suitable men is going to be a formidable task. The initial application, which can be made before discharge, will give full particulars concerning the man and his experience in farming; relevant details can be checked through Regional Soldier Settlement Authorities before the interview with the State Authority. The outlook of the farmer's wife is important, and the couple should be interviewed together. Lack of previous experience of farming should not debar a man from coming under the scheme.

Selected applicants should be divided into four classes:

- (1) Men suitable to assume farm ownership without further experience.
- (2) Men suitable to assume farm ownership, but for whom some short specialized training is desirable.
- (3) Men suitable for farm employment, but for whom further experience and training are necessary before they would be ready to assume farm ownership.
- (4) Men suitable for farm employment as trainees.

The training for men of class 2 should be provided at institutions and be of short duration, but training for the other classes would be on approved farms and at less than the ruling rates of pay according to the experience of the men. Some special

encouragement will have to be given to farm-owners to provide suitable premises for soldier employees, as there is an acute shortage of suitable accommodation on farms.

As a general guide to land settlement, the Commission emphasizes that there should be a reasonable expectancy of a sustained payable market for the produce, that full cognisance should be taken of soils, topography and general physical characteristics of the area, that farms should be of sufficient size to ensure a reasonable living and that some social amenities and facilities for social contacts should be available. The financing of the purchase of single farms for which the soldier has negotiated privately is not advisable, and any purchase of a farm should be made by the state authority. Crown lands considered suitable by the state authority should be made available to that authority, and it should also be given the power to acquire private lands by voluntary negotiation at their fair market value at 1st September, 1939. The acquisition of Crown lands and of private lands by voluntary negotiation will not yield sufficient land for the scheme, and powers to take the land compulsorily will most certainly have to be exercised.

The preparation of lands for allotment is an important question and, in general, no allotment should be made unless there is an adequate residence on the block, there is reasonable road access, and the farm is in such a state as to permit of the serviceman commencing active preparations for earning at least a sustenance income as soon as possible. The farms should be made available at a fair value, irrespective of the cost to the Crown, and the allotments should be made so that experienced men would have first choice, with the remainder submitted to ballot.

The creation of settlement opportunities will be a much slower process than the creation of farm employment opportunities and any settlement scheme should be available for at least five years.

There will have to be close supervision over both technical and financial aspects of the settler's work and the financing authority will have to protect itself as far as possible against misuse of the funds either directly, or by such devices as trafficking in concessions. All advances should, during the period of the first five years from the date of allotment of a holding, be free of interest during the next five years it should be two per cent., and thereafter at the current rate applicable to Commonwealth Mortgage Bank loans on farms. The interest concessions should enable the settler to obtain something like a 30 per cent. equity on his venture in ten years.

The farm-owner returned man is in a different category from the non-farm-owners, and each case for assistance will have to be considered on its merits.

Chapter 6.—Financial Responsibilities —Commonwealth and States.

The financing of settlers is considered to be a direct responsibility of the Commonwealth arising out of repatriation; with the exception of certain specific charges, most of the other expenses will be a matter for discussion between the Governments concerned.

In concluding the Report, the Commission emphasizes that it has considered fully the causes of failure in previous schemes and, in advancing a liberal scheme, does not attempt to minimize the difficulties to be faced by settlers and taxpayers alike.

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C. G. HUGHES.

Selection of Suitable Areas for the Settlement of Returned Men*

By

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The Rural Reconstruction Commission's plan for farm employment and land settlement for returned men is outlined in its Second Report, presented early this year. It is herein proposed to discuss one aspect of the plan, namely the selection of suitable areas of settlement, which is an aspect of agricultural policy in which members of the Institute may well be interested. Special attention is given to the number of ordinary farm holdings which normally change hands each year, and to the need for considering these holdings as suitable for settlement by returned men. The questions which it is suggested need answering in each State are as follows:

- (a) In what regions of the State do settlement opportunities exist?
- (b) What type of farm enterprise can most efficiently be conducted there?
- (c) What sized farm unit is most convenient for the given enterprise in the given region?
- (d) How many farms can be made available for settlement annually in the State?

Answers to these questions from the various branches of the Institute would be invaluable to any Commonwealth authority dealing with soldier settlement.

(a) Specific Regions for Settlement.

Certain proposals were made to the Rural Reconstruction Commission by departmental officers regarding areas in the various States thought to be suitable for investigation and possibly for settlement. Where details of the areas mentioned in evidence to the Commission have been published in the press it will be possible for those interested to scrutinise the proposals. Whether or not the details of the areas are made available to the general public, it would appear useful for the responsible State authorities to have the benefit of the informed opinion of members of the Institute on the various proposals.

If the Commission's proposal regarding classification of applicants (see para. 195 of the Second Report) is adopted, many of the original applicants will be required to engage in farm employment for several years before qualifying for farm ownership. For other reasons, too (given in para. 150), it is desirable to delay settlement for several years. This interim period offers time for the fullest consideration of settlement proposals, and it is to be hoped that the opportunity may be taken to turn this Institute's partially completed potentialities survey to some use in this connection. Dr. Richardson's original proposal⁽²⁾ and Professor Wadham's amplification⁽⁴⁾ of it outlined a method of approach to the assessment of Australia's agricultural potentialities which is equally suitable to this special aspect of the larger question. Articles by Professor Trumble⁽³⁾ and Mr. Lang⁽¹⁾ recorded some of the results obtained before the outbreak of war interrupted the continuation of the work.

(b) Suitable Types of Farm Enterprise.

A first approach to this question can be made by setting out in order of priority the types of commodities which the soils of the particular regions are best suited to

* Some of the figures quoted herein are taken from unpublished work of the author while working under a Post-war Reconstruction grant in the University of Western Australia.

produce, that is to say by constructing a productivity rating for each soil type concerned.

A final statement of the types of farm enterprise most suitable to each region can only be made after account has been taken of several other factors which include

- (i) the long-term marketing prospects for all relevant types of primary products,
- (ii) the technological trends in every relevant type of farm enterprise, and
- (iii) the accessibility of the particular regions to markets.

No attempt will be made here to predict the future trends under all these headings. But it may be of interest to outline the history of the three main types of farm holdings in Australia after the last war. In the first five years after the war the number of arable farm holdings increased in every State; this increase was twice as great as the increase in the number of dairy holdings. Pastoral holdings showed no increase. Since 1924 the total number of farm holdings in Australia has not increased appreciably. The number of pastoral holdings has again been stable. The number of arable holdings has fallen in every state except Queensland. In Western Australia and South Australia this fall in arable holdings has been offset by an increase in the dairy and pastoral holdings. In New South Wales, Victoria and Tasmania the increase in dairy holdings was insufficient to offset the fall in arable holdings. It is contended that the main cause for the general fall in the number of arable holdings was the decline in wheat prices from 1929 onwards; while the main cause for the partially compensating expansion in dairy holdings was probably the combination of a growing home market and a sheltered export market in Britain. From these facts we may conclude that unless substantial overseas markets for our main primary products are guaranteed at reasonable prices in the immediate post-war period, there will be no permanent increase in the number of pastoral or arable wheat holdings, and only a very slow increase in dairy holdings. There may be some expansion in arable farming for products other than wheat.

(c) Farm Size.

The factors mentioned in the preceding section are also important in determining farm size, and will not be elaborated here. One other factor determining the most suitable size of farms will be briefly mentioned. It is the optimum division of labour and management within the farming industry, or in quantitative terms the man / holding ratio. It has been calculated that the average man / holding ratio in Australia has remained fairly steady over the past 30 years at $1\frac{1}{2}$ men per holding. Over that time the increase in the number of holdings has just kept pace with the increase in the numbers of men permanently engaged in the industry. It seems unlikely that the number of holdings can continue to increase at the same rate much longer. There will be a natural tendency towards a rise in the ratio of men to holdings. It may be possible for this rise to go along with increasing, rather than diminishing, returns if we can revise our ideas about the virtue of one-man holdings, if farm sizes are adjusted accordingly, and if we can improve the conditions of employed farm workers.

(d) Number of Farms Available Annually.

It is desirable that a quantitative estimate of settlement opportunities should be made, as it has already been agreed that "the number to be settled will be determined by settlement opportunities rather than by the number of applicants". The settlement authorities will need a quantitative estimate of settlement opportunities to guide them in their application of the principles laid down for selecting farm applicants. The types of farm holdings to be made available can be considered under three headings:

- (i) Pioneer holdings.
- (ii) Closer Settlement holdings.
- (iii) Ordinary holdings transferred.

(i) Pioneer holdings will be available to a limited extent on suitable unalienated Crown lands. The Rural Reconstruction Commission stated, in its Second Report, that "any future scheme for developing Crown lands for farming settlement should be located in the better rainfall coastal areas of equable climate". When this matter is being considered quantitatively, it should be borne in mind that the average increment in numbers of farm holdings in Australia over the 20 years 1919 to 1939 was only one thousand farms a year. That figure takes account of the increment in pioneer farms and closer settlement farms less the decrement in the numbers of ordinary farm holdings.

(ii) Closer settlement holdings will probably become available in the proved agricultural districts in some instances where the past owners of large holdings have neglected to improve fully their methods of land use. The success of new settlers on these holdings will hinge on the success with which the value of the land and its transfer for this purpose can be controlled. It becomes necessary to provide for closer settlement in a community where there is little suitable unoccupied land, if at the same time the population is growing and the number of men wishing to become farmers is increasing. In the process of closer settlement the size of individual holdings is reduced, and the number of farm operators is increased. In the course of agricultural progress over the past 150 years in Australia, pastoral holdings have fallen from first to third place, being outstripped in numbers first by arable holdings, and then since the last war by dairy holdings. Each of these closer settlement developments has tended to reduce the average size of farm holdings. If expanding markets become available, say, for tobacco, potatoes, rice or other minor crops, then it seems likely that the closer settlement of the larger farm holdings will continue for the purpose of converting some land to these more intensive uses. Some such closer settlement will occur, but the total number of new holdings, so created, probably will not be sufficient to prevent a simultaneous rise in the average man/holding ratio.

(iii) Transfers of ordinary farm holdings in Australia in the normal course of events probably number about eight thousand holdings a year (this figure being based on an estimated average individual tenure of thirty years). It is herein proposed (see Table I) that the bulk of the holdings made available to returned men should be ordinary farm holdings, thousands of which mature for transfer every year. The Second Report of the Commission has stressed "the need for extreme caution with this type of purchase" (see para. 205), largely because "it is almost universally true that the market value of a farm is equal to or in excess of its earning capacity" (see para. 143). In its estimates the Commission allows an average of over £3,000 per head for the cost of establishing a settler. The present writer contends that, in spite of the Commission's doubts, this money is likely to be better spent from the settler's point of view in purchasing and improving a farm taken over as a going concern in a good district at a controlled price, than in financing the clearing and development of virgin Crown land. Also in the latter case fairly heavy additional costs would probably fall on the community for the provision of essential services to the area. Both pioneer settlement and closer settlement holdings must be to some extent experimental. While there is good reason to encourage experimentation, returned men should not be used in the experiments. Providing the selection of applicants is well done there need be no fear (para. 205) that successful civilian farmers would be replaced by inexperienced returned men, if returned men were settled on transferred holdings. It would rather be a case of older farmers retiring and being replaced by young well trained men. The Commission states that when transfers of ordinary holdings are made they should be made to the soldier settlement

authority at a fair value, and not to the returned man personally at market value (see para. 206). This precaution cannot be overemphasized. All farm transfers and all rural land values will probably have to be controlled. Far more people want to live on the land in Australia than can possibly make a reasonable living there. If the community considers that returned men should be given preference to adopt a life on the land, then the best way to give them a good start is to see that they get a fair selection of all current farm transfers.

TABLE 1.

Number of Rural Holdings (in Thousands) to be made Available over a Period of Five Years for the Settlement of Returned Men.

	Pioneer Settlement.	Closer Settlement.	Transfer of Ordinary Holdings.	Transfers Deferred in War Period.	Total.
New South Wales ..	1	7	9	5	22
Victoria ..	0	4	10	6	21
Queensland ..	1	8	4	2	14
South Australia ..	0	2	4	2	9
Western Australia ..	0	1	3	2	6
Tasmania ..	0	1	2	1	3
Commonwealth ..	2	23	32	18	75

TABLE 2.

Number of Soldier Settlement Holdings.

	Per Hundred Returned Soldiers in 1933.	Per Hundred of all Rural Holdings in 1929.	Per Thousand of State's Population in 1929.
Queensland	3	3	1
Tasmania	7	6	3
New South Wales	7	9	2
Victoria	9	9	4
South Australia	11	9	4
Western Australia	12	14	6
Weighted Commonwealth Average	8	8	3

Quantitative Assessment.

To be most useful, the answers to the four questions posed should be in quantitative and not purely descriptive terms. The figures in Table 1 are offered tentatively in the attempt to set the problem in quantitative terms. It may be noted that a higher total is reached than the figure of 54,000 mentioned by the Rural Reconstruction Commission (see para. 152). Briefly it may be said that the figures in Table I purport to represent the upper limits of physical possibility under present-day

Australian institutions; they are based on the "settlement opportunities rather than the numbers of applicants". Very briefly it may be added that columns (1) and (2) are based on an assessment of probable market prospects, soils and climate, whilst the figures in columns (3) and (4) are based on the numbers of existing farm holdings with certain adjustments.

Finally, it may be of interest to quote (Table 2) some figures recording the comparative results of soldier settlement in the various States after the last war.

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1. Lang, P. S.: J. Aust. Inst. Agric. Sci., 5: 46-49, 1939.
2. Richardson, A. E. V.: *Idem*, 3: 3-18, 1937.
3. Trumble, H. C.: *Idem*, 5: 38-45, 1939.
4. Wadham, S. M.: *Idem*, 3: 123-128, 1937.

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Factors Affecting the Efficient Production of Supplementary Pasturage and Fodder under Partial Irrigation

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The relative insufficiency of conservable water as compared with the area of land in Australia that could benefit by irrigation necessitates a high degree of efficiency of water usage. The tendency of late years to make water available to a small portion of each livestock holding within large irrigation districts in regions of low and/or erratic rainfall, for the purposes of stabilizing stock numbers and animal production, was discussed by the author in a previous article⁽²⁸⁾ in which the economics of such water usage were more than favourably compared with the production of other crops in concentrated irrigation areas. It was pointed out that the attainment of maximal wool (and meat) production, having regard both to quality and quantity, from stock grazed on natural pastures, supplemented with pasturage or fodder from irrigated land, depended mainly on the efficiency of assimilation of available plant protein per unit of water used. It is the intention here to discuss the factors that affect such efficient production, particularly as they apply to the Murray and Murrumbidgee Rivers irrigation districts.

The Soil.

Soil Fertility.

Irrigation should be restricted as far as possible to those soil types within an area which are the most productive per unit of water applied by reason of their natural fertility. Ease of establishment and of irrigation management should be considered in the choice of soil type. For these reasons soil surveys are of extreme value in preliminary assessments of the worth of various types and their suitability for irrigation.

The efficient use of water—either as rainfall or irrigation—by plants is intimately connected with the provision of adequate plant nutrients. The ratio of dry matter formed to water transpired by the plant increases as plant nutrients are increased to their optimum.* The determination of fertilizer requirements is a most important aspect of efficient water usage, and where, as in the extensive irrigation districts, water is limited and fertilizers should be readily procurable, optimal water efficiency demands full and correct manuring practices.

Soil Moisture.

Efficient water usage necessitates the application at each irrigation of a volume sufficient to wet the complete depth of root zone, but no further. To this end a knowledge of soil moisture constants and of root systems is required for each species or mixture of species in each soil type.

* This may probably be a physiological response, but is also possibly the result of the development of a more intensive and extensive root system, with consequent greater volume of soil being made available for moisture and mineral exploitation.

A brief outline is here given of the modern theory of soil moisture.^(6, 11, 25, 26) In Figure 1, the total soil volume is graphically separated into its five components, namely "soil minerals", "unavailable water", "slowly available water", "readily available water" and "air and roots". In any one soil the dividing lines are constants, so that within a given depth the maximal volume of water which is readily and less readily available for plant growth is a constant (the horizontally shaded area). The soil might be regarded as a reservoir of water available for plant growth, with upper and lower limits. Below the limits plants cannot extract moisture, and above the limits percolation to greater depths takes place, or, if this is prevented by an impenetrable layer, then the extra moisture is held at the expense of soil air, and plant roots suffer.

Figure 1.

- i-iv. Diagrammatic representation, in a theoretical soil type, of the soil moisture constants.
 - (i) The horizontally shaded area shows the total water available to plants immediately after an irrigation that has wetted the root zone.
 - (ii) Loss of water by evaporation and by transpiration to near wilting has reduced the available water.
 - (iii) An insufficient amount of water applied to (ii) would leave some of the root zone unwetted.
 - (iv) An excess amount of water applied to (ii), and with poor drainage, would saturate the lower levels of the root zone, excluding air therefrom.
- v. Diagrammatic representation of another soil type that naturally lacks sufficient soil air below the 2 ft. depth, thereby restricting root growth to above this level. After Woodruff.⁽²⁹⁾

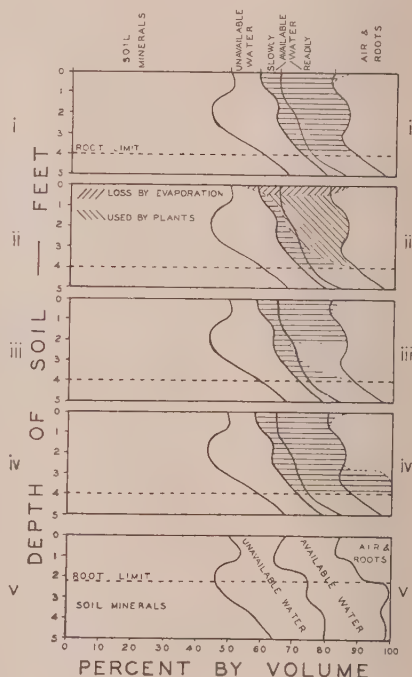


Figure 1 (i) represents a soil that has been recently fully watered, that has free drainage underneath, and that has not been deprived of any of its moisture by evaporation or plant transpiration. Assuming plant roots extend into this soil to a depth of four feet, and that in common with most plants the concentration of roots is greatest in the upper horizons and decreases with depth, then, when temperature and light conditions are satisfactory for plant transpiration, moisture is extracted, each soil layer losing water proportionately to the concentration of roots it contains. When all the "readily available water" in any one layer has been extracted, the plant experiences difficulty in obtaining water from the "slowly available" supply, and has to depend more and more on the lower layers. As these are depleted, wilting finally occurs, and the soil moisture status becomes as shown in Figure 1 (ii).

It will be noted in Figure 1 (i) that the surface soil layers after wetting retain a volume of water greater than the true field capacity,⁽²⁷⁾ and that in 1 (ii) the same layers have lost water below the Ultimate Wilting Point, this condition being reached very shortly after an irrigation. This loss is in greatest measure due to direct evaporation which affects the surface layers to a depth depending on the nature of the soil, the protective cover of plants and the evaporative intensity. In this upper layer, plant roots also do extract moisture, but the greatest extraction is by air passing through the soil interstices and drying it out. When the moisture is reduced to the Ultimate Wilting Point the roots can no longer absorb water but evaporation proceeds until air-dryness is reached.

This evaporative loss, occurring as it does during and immediately after each irrigation, is a constant amount, and the quantity lost per season can only be reduced by reducing the number of waterings. Also, if in the soil illustrated in Figure 1 (i-iv) plants were grown that had a root limit of only two feet (instead of four feet) and water was added sufficient to wet to that depth only, the proportion of water added that would be lost by evaporation would be increased. If plants were grown with an effective root system extending to six feet depth, the proportion lost by evaporation would be decreased. Also such deeper rooting plants by allowing of heavier irrigations would result in more water being stored within the root zone at each irrigation, and consequently the time interval between irrigations could be lengthened and the number of waterings per season reduced, thereby decreasing the total evaporative loss.

To fully replenish the soil shown in Figure 1 (ii) with water, a volume equal to that extracted by plants and by evaporation must be added. If less than this is applied then the soil is wetted to only a portion of its depth as in Figure 1 (iii) (not partially wetted to its full depth). This happens because each portion of a soil must be at Field Capacity or above before water flows through it. Such shallow watering results in a greater proportion being lost by evaporation, a restriction of the root zone and consequent scope of mineral exploitation to the wetted depths, and a necessity for more frequent waterings. If more water than has been removed by plants and by evaporation is added, which is a very common practice,⁽¹⁶⁾ then the excess percolates below the limits of the roots and is wasted, because there is normally no upflow of water from below. This percolate also leaches plant nutrients out of range of the roots. If there is not sufficient drainage for this excess to pass away, then the lower levels of the soil become saturated, water entering the normal air spaces and displacing the air, and a "water table" is created. Additions to this excess over a period of time result in a gradual rise in the saturated level, which, entering the root zone, inhibits root growth due to lack of aeration, Figure 1 (iv). The further the saturated level rises into the root zone, the more roots are adversely affected. Should it ultimately reach the soil surface evaporation takes place there and an upward movement of water from below proceeds (since the soil moisture is now above Field Capacity), and any dissolved salts are deposited.^(23, 27) Such a condition is well known and its seriousness need not be stressed.

The depth to which roots penetrate, granted suitable moisture conditions, depends upon the species or strain of the plant and upon the soil type. For any one strain upon any one soil type, it is a constant, and within that depth the amount of available water that the soil can hold is a constant, and may be designated "C". When the soil moisture is reduced to its minimal capacity by plants, then the application of quantity "C" will re-wet the soil to the depth of the root zone. If the soil is not reduced to its minimal capacity and water is applied, a less quantity than "C" will wet to the same depth. "C" itself would wet the zone of the root system and there would be an excess which would either penetrate to lower depths, or else saturate, with adverse effects, soil within the root zone. The main point, however, is that there is for each soil type and the associated plant growing thereon a maximal amount "C" to apply at each irrigation, and this should never be exceeded, and very often less will be required. The soil moisture constants should be incorporated in the soil survey, as has been done, for example, at Waikerie,⁽¹³⁾ and the determination of specific root depth could be made by simple trial. "C" could then be readily calculated.

Soil Air.

Besides the instance where excess irrigation is greater than can be coped with by drainage, with consequent filling of the air spaces by water, some soils by their structure lack sufficient soil air. Woodruff⁽²⁹⁾ has demonstrated that in these soils the volume of soil pore space required to accommodate sufficient water for plant growth may be so great as to exclude the minimal amount of air necessary for plant development. That is, certain soil layers may be well supplied with available water for plant growth, but owing to lack of aeration roots cannot extend down into them. This is illustrated in Figure 1 (v). Consequently, plants have to depend for their water on whatever moisture is available above the impenetrable layer. The closer this layer is to the surface the less is the depth of the roots with a like reduction in the volume of water available to the plants. This entails more frequent irrigation, perhaps to such a point that they may become impracticable.

Such a condition may apply on the heavy grey soil types in the Riverina where difficulty has been experienced in establishing and maintaining sown pastures. Future irrigation projects should be surveyed with regard to this "soil-soil water-soil air-plant root" complex. Areas already established on what at present appear to be unsatisfactory soil types require that attempts be made to determine practical methods of preconditioning the soil by specialized cropping or mechanical means before the establishment of the sown pasture.

The Plant.

Species or strains of pasture or fodder plants should be selected for the following ideal characteristics :

- (1) Suitability to the climate and soil.
- (2) High seasonal yield.
- (3) Palatability.
- (4) High protein and mineral content.
- (5) Persistence under grazing and under irrigation.
- (6) Low transpirational requirement to obtain high yields per unit of water.
- (7) Deep root system, the lower the root limit resulting in a greater volume of available water (C) being commanded per irrigation, individual irrigations thereby being more heavy, and the number of applications reduced.
- (8) Intensive root system, so that the soil moisture within each layer can be fully exploited at each watering, with consequent lengthening of the time intervals between irrigations.
- (9) Suitability for fodder conservation (as grain, hay or ensilage).

The present large-scale irrigation of natural pastures constitutes a serious water loss. The natural pastures consist mainly of winter annuals, most of which are relatively shallow rooted, and since it is extremely difficult to apply small amounts of water to large paddocks, large quantities are generally given. The soil is thereby wet to greater depths than the roots can exploit, and a continuation of the practice under the prevailing poor drainage conditions can rapidly lead to waterlogging and surface salt accumulation. Bad as is the practice of irrigating winter growing native pastures in autumn and spring, summer irrigation of these to obtain growth from sparse summer annuals is much worse.

The choice of suitable species and strains for sown pastures is largely a matter of trial, Wimmera ryegrass and subterranean clover being at present the most common winter mixture, and lucerne the summer species in the irrigated Riverina. White clover has not given promising results at Wakool until the third year. Perennial ryegrass and *Phalaris* have often proved difficult if not impossible to establish, and even subterranean clover, on some soils, has been disappointing. Preliminary investigations are required on the establishment of desirable species, and on fertility building by the use of legumes.

Owing to the heavy labour requirements, fodder cropping does not appeal to the Riverina irrigation grazier at present, but where the objective is to conserve feed for drought periods, greater importance may be attached to such crops.

The Plant and its Relation to Soil Moisture.

The determination of the correct time to irrigate depends primarily upon the rate at which the growing plants extract the available water from the soil, and secondarily upon the response of the plant to irrigation at varying periods during this extraction process.

After an irrigation where the soil is wetted to the depth of the root zone the plants extract water from the soil in proportion to the concentration of roots in each layer.^(1, 20) The soil in the vicinity of the highest root concentration is the first to be reduced to its minimum moisture capacity, followed in turn by zones of less and less root concentration. Finally the plant reaches a stage where water is becoming seriously limiting to its growth and it shows signs of wilting.

Two theories have been propounded as to the growth behaviour of plants between irrigation and wilting. They may be stated as follows :

1. The growth rate of plants in the field is not affected by a decreasing moisture availability until the greater portion of the soil within the root zone is reduced to the Wilting Range (that is between the First Wilting Point and Ultimate Wilting Point).^(8, 17, 22, 25)
2. The growth rate gradually diminishes as increasing proportions of the soil within the root zone are reduced to the Wilting Range.^(10, 14, 15, 18)

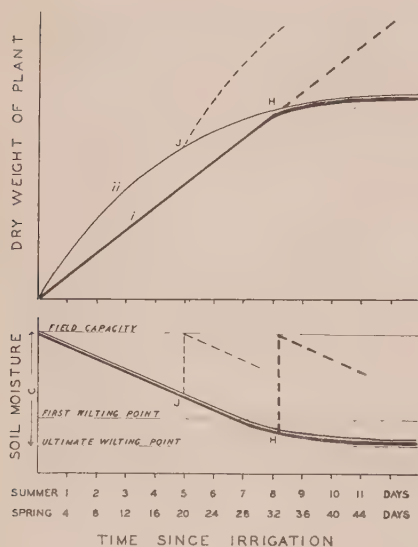


Figure 2.

Theoretical curves of plant growth between an irrigation and subsequent wilting as related to the curve of extraction of available soil moisture within the root zone. Broken lines refer to re-irrigations. Curve (i) after Veihmeyer⁽²⁵⁾; curve (ii) after Lewis, Work and Aldrich.⁽¹⁵⁾

Climatic and atmospheric conditions such as temperature, light intensity, wind movement, and air humidity, control directly and indirectly the transpiration of water from the plants to the atmosphere, and this transpired water is replaced by moisture extracted from the soil. Consequently in periods of high transpiration all of the available moisture is extracted from the soil within a much shorter space of time than in periods of low transpiration. In Figure 2 point H may be reached in mid-summer within, say, eight days from an irrigation, but in spring after perhaps a month or more. Irrigations at, for example, 14-day intervals throughout the season would be much too early to benefit in spring, and probably too late to prevent serious wilting and even death during the summer.

Suppose that the curve of extraction of moisture from the soil over the season could be delineated for a soil type and crop grown thereon, as in Figure 3. "C" is the quantity of available water that the soil can hold in the root zone, and is therefore the constant amount necessary at each irrigation if the soil is allowed to dry to its minimum before each application. When quantity "C" has been extracted from the soil by the plants, quantity "C" is re-applied as an irrigation. The projection of these points of intersection with the curve on to the "time abscissa" gives the dates when irrigations are to be performed. On the other hand if as illustrated in Figure 4, it is desired to give irrigations, for example, every 21 days, and to vary the amounts, the quantities at each irrigation are obtained by projecting the points of intersection of equal time intervals (L) with the curve on to the "quantity ordinate". Thus the amounts to apply to wet the full depth of the root zone and no more become M, N, O, P, Q, R, etc., in that order. If any of these quantities are greater than "C", then the time interval is too long, and must be shortened until the greatest quantity is reduced to "C".

The disadvantages of equal irrigation intervals as compared to equal irrigation amounts are:

1. More applications are necessary.
2. Care is required to apply the correct amount evenly at each irrigation, since it often consists of small quantities which are difficult to spread.

This is illustrated in Figure 2. If case (1) is correct, then obviously no increase in yield may be expected by watering before point H. If case (2) is correct, increases will be obtained by irrigating at point J for example. On areas of intensive production where there is no severe limitation to the quantities of water available, there is an urgent necessity to determine which of these views applies, for on it depends the irrigation interval and the resultant yield. However, on pastoral areas with limited water supply and the necessity of keeping the number of irrigations per season to a minimum, it is not thought that any economic advantage can be gained by irrigating before point H. In fact it may be desirable, as discussed later, to postpone the watering to some time after H. Watering at point H or later simplifies the determination of the correct amount of water to apply at each irrigation. As can be seen from Figure 2, after point H the rate of loss of moisture from the soil through the plants is greatly diminished, and the soil approaches its Ultimate Wilting Point very slowly. From H onwards the addition of known amount "C" re-wets the complete depth of root zone, and if it is in excess, the excess is not great. Irrigation at point J would need to be less than "C" to prevent overwatering. Obviously it is easier to apply a fixed amount at each irrigation than to attempt to calculate and apply a different amount at each irrigation.

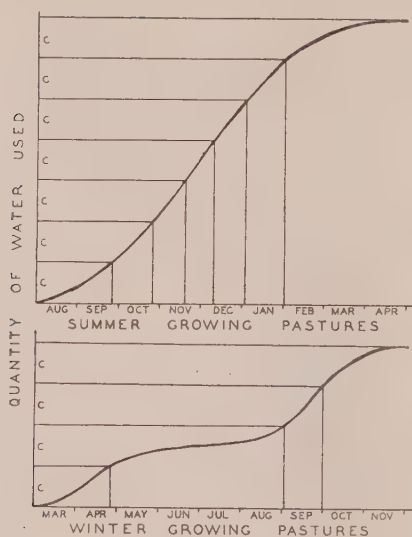


Figure 3.

Equal irrigation amount. Determination of irrigation dates, knowing theoretical curve of extraction of soil moisture, and quantity of available water that the soil will hold, "C". Rainfall not taken into account.

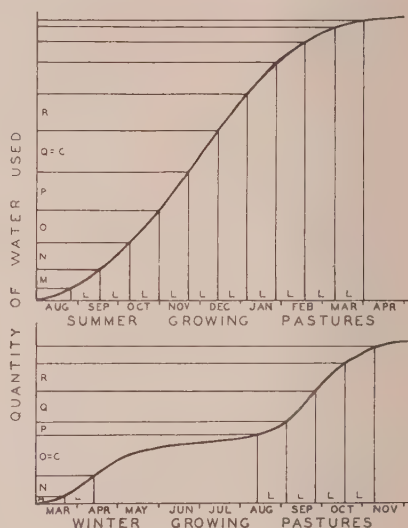


Figure 4.

Equal irrigation interval. Determination of correct irrigation amount, knowing theoretical curve of extraction of soil moisture, and quantity of available water that the soil will hold, "C". Rainfall not taken into account.

3. In the early and late parts of the season the plants are being irrigated whilst there is still a sufficiency of water in the soil. Martin⁽¹⁸⁾ has critically confirmed earlier work in which it has been shown that immediately after an irrigation plants transpire water very freely and the ratio of growth to water transpired is low. As the moisture in the soil is reduced the ratio of growth per unit of water used increases. So that if irrigations are given before the water supply in the soil is materially reduced the plant is continually kept in an environment in which it functions inefficiently as regards water usage.

From the above it is obvious that equal irrigation intervals should not be the rule in irrigation practice.

As mentioned earlier, it may be desirable in the interests of water efficiency to delay each irrigation after point H in Figure 2 for as long as possible without seriously injuring the plants, as in Figure 5. The reasons for this are:

1. As shown above, plants become more efficient in their use of water as the soil moisture is reduced.
2. There is evidence that, in many cases, plants become hardened and better able to withstand subsequent periods of moisture shortage if they are frequently allowed to suffer water deficits by withholding irrigation. This drought hardening process may be partly physiological, Vassiliev and Vassiliev⁽²⁴⁾ assuming that it is due to hemicellulose accumulation. But it is also in great degree due to the roots being forced to ramify to greater depths and intensity when young in order to obtain water if irrigations are withheld; which extensive and intensive root system stands them in good stead in subsequent temporary droughts.
3. By allowing the plants to suffer water deficits their water content or succulency is reduced, and this may have important bearing on the health of the animals consuming the pasture. Stock grazed between dry land pastures and irrigated pastures are not so liable to scours, bloat, staggers or internal parasites if the succulency of the irrigated pasture is reduced as far as possible.
4. Experience with wheat has shown that water deficits in the plant increase protein synthesis.⁽¹⁹⁾ If this is true for pasture plants, it is exactly what is required in the irrigation areas, namely the production of protein for the least expenditure of water.

5. Lengthening the period between irrigations reduces the number of applications necessary per season, which results in lowered labour costs.
6. The fewer the number of irrigations per season, the less is the amount of water lost by direct evaporation during and immediately following each irrigation.
7. With less water used in the season on each acre, greater proportions of each property could be irrigated. This involves lower yields per acre and increased costs of irrigation facilities, but the benefits are a greater area of land producing high quality products at a minimal expenditure of water.

There is, however, a possibly serious disadvantage in delaying irrigations until water deficits within the plant become severe. This is that water stress apparently tends to produce indigestible lignin, which, being formed in the cell wall, acts as a barrier to the utilization by the grazing animal of the enclosed protein.

The time to apply water must be determined, bearing in mind that the function of the irrigated portion of each property is not to give a balanced pasture in itself, but to act as a complete supplement to the much larger dry land area. This inter-irrigation interval necessitates the delineation of the curve of extraction of soil moisture (Figures 3 and 5) and its relation to the curve of accumulation of assimilable protein; plus the determination of the length of time that plants can be allowed to suffer water deficits without danger of permanent injury ("S" in Figure 5).

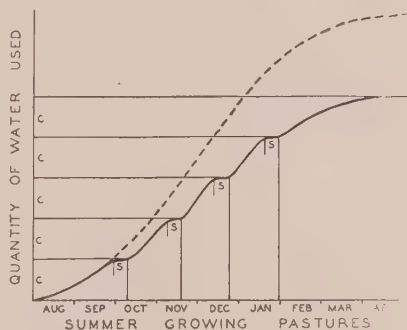


Figure 5.

Equal irrigation amount. Effect on theoretical seasonal soil moisture extraction curve of delaying each irrigation for a period "S" after practically all available soil moisture has been extracted by plants.

Work on the delineation of these curves in overseas irrigation has been done with crops that either

1. have a more or less constant surface area of transpiring leaf—for example, citrus trees,⁽¹¹⁾ or
2. have a gradually increasing surface area of transpiring leaf—for example, sugar cane.⁽²²⁾

However, in a pasture the surface area of transpiring leaf alternates between a gradual increase by growth, and defoliation by the grazing animal or hay mower. Grazing management therefore has an important bearing on the curves of soil moisture extraction and growth accumulation.

Overseas methods of delineation of the soil moisture extraction curve have been on the following lines:

1. Direct soil moisture measurement by very frequent sampling to determine the rate of usage of available soil moisture. Quite recently new electrical measuring instruments have been devised with a view to considerably simplifying the work involved in obtaining soil moisture at frequent intervals.^(2, 3, 4, 21)
2. Climatic measurements, on the assumption that measurable climatic and atmospheric factors are directly correlated with transpiration, and that this is closely correlated with extraction of moisture from the soil.^(6, 9)
3. Plant measurements:
 - (a) Frequent growth measurements to determine any severe slowing of growth due to approaching exhaustion of the available soil moisture; for example, the daily measurement of the circumference of citrus fruits⁽¹¹⁾ or of the height of sugar cane stalks.⁽²²⁾
 - (b) Frequent determination of the moisture content of selected plant tissue, for example the elongating sheaths of sugar cane, on the assumption that a shortage of available moisture in the soil manifests itself in low moisture content in the plant tissue.⁽⁷⁾

Irrigation.

The application of the correct amount of water at the correct times requires both efficient watering methods and suitable availability of supply. It is obvious that no artificial watering method suitable for extensive irrigation can evenly spread water over a paddock so that the root zone, no more no less, is wetted in all portions of that paddock. However, the contour system described by Hall⁽¹²⁾ appears to be a particularly efficient method of large-scale watering, but data on infiltration rates, etc., are necessary for determining the correct size of bays on each soil type.

Having determined the quantities of water required at different periods of the year for each paddock, total diversions for a whole district can be fitted to these needs, and the remainder of the water left in storage. Community irrigation, demanding as it does discipline and cooperation among water users, is an important factor in water economy.

Grazing Management.

The determination of proper grazing rotations between the dry land and irrigated land is essential to balance the diet so that liveweights may be maintained, the uniformity of wool growth both in fibre length and diameter preserved, and the health of the stock assured. At the same time both the dry land and irrigated pastures must be managed to prevent deterioration of either.

Grazing rotations and hay cutting have to be adapted to the irrigated pastures to preserve high yields per unit of water used. (For example, as plants flower, the ratio of water transpired to dry matter produced increases.)

To reduce evaporation and increase percolation a good surface plant cover is required. The common practice of irrigating immediately after grazing should ideally give place to grazing whilst there is still enough moisture in the soil to continue plant growth, so that after the stock are removed a better covering could be re-established by the time the next watering is required. However, the land should not be grazed while the soil is in such a condition that surface compaction by trampling might occur.

Co-ordination.

All the preceding factors which together influence efficient water usage require elucidation. Co-ordination of such data into terms of practical pastoral irrigation is a necessary preliminary to the determination of the type of livestock that can most benefit from conserved water supplies, be it meat or wool production, and is concomitant with the optimal usage on the chosen type or types.

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INDEX

TO VOLUME 10

	Page.		Page.
A			
Agricultural Economics, Production-Cost Studies in	31	<i>Comperiella bifasciata</i>	38
" Education in Western Australia	1	Correspondence	41, 185
" " " England and Wales	6	Cost of Production Studies	31, 185
" Science, The Australian Institute of 39, 83, 131, 178		Council of A.I.A.S., Meetings .. 39, 83, 131, 179	
Agriculture, Economic Factors Preventing Change in	140	Cultures, Preservation with Liquid Paraffin of Fungi and Bacteria in Tube	77
Aird, J. A.—		D	
Milking Machines on Dairy Farms ..	41	Dairy Farms, Milking Machines on ..	41, 42
American Soil-Conservation Methods ..	184	Deficiency Symptoms in Citrus, Copper ..	176
Antagonism, Manganese-Iron	186	Defries, C. H.—	
<i>Aonidiella aurantii</i>	38	Production Cost Studies	185
Arbitration Machinery and Salaries	182	Doctorate Conferred—W. A. T. Summer-ville	183
Areas Suitable for Settlement of Returned Men	152	E	
Aspects of Plant Pathology in Western Australia	93	Economic Factors Preventing Change in Agriculture	141
Australia, Need for Wool Research in ..	108	Economics, Production Cost Studies as a Field of Research in	31
Australian Capital Territory Branch of A.I.A.S.	83	Education, Agricultural, in Western Australia	1
Australian Food Position	13	" " " England and Wales	6
" Primary Industry, Application of Science to	135	Edwards, E. T.—	
B		The Australian Food Position	13
Bacterial Plant Pathogens, the Genetic Names of	78	Efficiency in the Rural Industries	45
Balance Sheet of A.I.A.S.	180	England, Agricultural Education in	6
Beans, Varietal Resistance to Halo Blight in	76	Erratum	138
Book Reviews	42, 89, 139, 187	Eye, Resolving Power and Wool Classing ..	175
A Source Book of Agricultural Chemistry, by C. A. Browne	139	F	
Bacterial Spoilage of Fortified Wines, by J. C. M. Fornachon	42	Flax, Phoma Stem Disease of	129
Insect Pests and their Control, by J. W. Evans	89	Fodder Production Under Partial Irrigation	157
Lectures on the Inorganic Nutrition of Plants, by D. R. Hodgland	91	Food Situation, World	137
Photoperiodism in the Potato, by C. M. Driver and J. G. Hawkes	187	" and Farming in Post-War Europe ..	88
Plants and Vitamins, by W. H. Schopfer	90	" Australian Position	13
Plant Viruses and Virus Diseases, by F. C. Bawden	90	Fruits, Preservation of by Quick Freezing	114
Potato Collecting Expeditions in Mexico and South America. II. Systematic Classification of the Collections, by J. G. Hawkes	187	Functions of Mineral Elements in Plant Nutrition	122
Supplement to Studies on the Identification of Timbers, by Alexander L. Howard	187	G	
The Production of Seed of Root Crops and Vegetables	89	General Meeting of A.I.A.S.	135, 178
Vegetable Matter in the New South Wales Wool Clip, by G. J. Milthorpe ..	187	Generic Names of Bacterial Plant Pathogens	78
Bradfield Irrigation Scheme, Climatic Aspects	165	Glasscock, Clarence Parsons (Obituary) ..	139
Branches of A.I.A.S. Meetings, 40, 83, 131, 179		H	
C		Hall, E. G.—	
Campbell, K. O.—		The Preservation of Fruit and Vegetables by Quick Freezing	114
Production-Cost Studies as a Field of Research in Agricultural Economics ..	31	" and Trout, S. A.—	
Cattle Industries, Summer-Rainfall Pastures and	25	Some Effects of Waxing on Weight Loss from Oranges and Certain Vegetables	80
Christian, C. S.—		Halo Blight in Beans, Varietal Resistance to	76
Summer-Rainfall Pastures and the Cattle Industries	25	Henrick, James Oscar (Obituary) ..	92
Citrus, Copper Deficiency Symptoms in Climatic Aspects of Bradfield Irrigation Scheme	165	Horticultural Development of Queensland Host Fruit, Effect upon the Scale in Relation to its Parasite	38
I			
		Institute of Agricultural Science, The Australian	39, 83, 131, 178
		Iron-Manganese Antagonism	186
		Irrigation and the Wool Industry	102
		" Climatic Aspect of Bradfield Scheme	165
		" Production of Pasture and Fodder under	157

INDEX

iii

	Page.
L	
Land Use, Surveys for Potential	20
" in South Australia	144
Lang, W. R.—	
The Resolving Power of the Eye and	
the Classing of Wool	175
Leeper, G. W.—	
Manganese-Iron Antagonism in Plants	186
M	
Macindoe, S. L.—	
Milking Machines on Dairy Farms ..	42
McTaggart, Alexander (Obituary)	140
Manganese-Iron Antagonism	186
Marshall, Ann—	
Climatic Aspects of the Bradfield	
Scheme	165
Meetings of A.I.A.S.—	
Branch	40, 83, 131, 179
Council	39, 83, 131, 179
General	135, 178
Milking Machines on Dairy Farms	41
Millikan, C. R.—	
Phoma Stem Disease of Flax	129
Millthorpe, F. L.—	
The Function of Mineral Elements in	
Plant Nutrition	122
Mineral Elements in Plant Nutrition ..	122
N	
Need for Wool Research in Australia ..	108
New South Wales, Branch of A.I.A.S. ..	40, 83, 131, 179
" " " " Report to Rural	
Reconstruction	
Commission ..	46
" " " Report Primary Pro-	
ducers' Association	
on Rural Recon-	
struction	43
Norris, D.—	
Preservation of Tube Cultures of Fungi	
and Bacteria with Liquid Paraffin ..	77
O	
Obituary Notices	44, 92, 139, 140
Oranges, Effects of Waxing on Weight	
Loss from	80
P	
Paraffin, Preservation of Tube Cultures	
of Fungi and Bacteria with Liquid	
Pastures, Summer-Rainfall and the	
Cattle Industries	25
Pastures under Partial Irrigation	157
Pathogens, Generic Names of Bacterial	
Plant	78
Personal Notes	44, 92, 140, 188
Phoma Stem Disease of Flax	129
" <i>exigua</i>	129
" <i>unicola</i>	129
Plant Nutrition, Function of Mineral	
Elements in	122
Plant Pathology in Western Australia ..	93
Preservation of Fruits and Vegetables by	
Quick Freezing	114
" of Tube Cultures of Fungi	
and Bacteria with Liquid	
Paraffin	77
Primary Producers' Association, Report	
Production-Cost Studies	31, 185
<i>Pseudomonas medicaginis</i> var. <i>phaseoli-</i>	
<i>cola</i>	76
Q	
Queensland Branch of A.I.A.S.	40, 84, 131
" Horticultural Development in	
" Journal of Agricultural	
Science	86
Quick Freezing, Preservation of Fruits	
and Vegetables by	114

	Page.
R	
Rainfall, Pastures and Cattle Industries	
under Summer	25
Ramsay, A. M.—	
Economic Factors Preventing Change	
in Agriculture with Special Refer-	
ence to Wheat Growing	140
Raphael, T. D., and White, N. H.—	
Varietal Resistance to Halo Blight in	
Beans	76
Reconstruction Commission, Rural—	
First Report	65
Second Report	148
Report of Western Australian Branch	
1	46
Report of New South Wales Branch ..	69
Research and Future of Wool	69
Resistance to Halo Blight of Bean	
Varieties	76
Returned Soldier Settlement in Post-War	
Period ..	148
" " " Suitable	
Areas for	
Rice Production on the Wakool Irriga-	
tion Area	87
Rowley, Sheila—	
Selection of Suitable Areas for the	
Settlement of Returned Men	152
Ross, I. Clunies—	
The Need for Wool Research in Aus-	
tralia	108
Rural Industries, Technical Efficiency in	
45	
S	
Salaries and Arbitration	182
Scale, Effect of Host Fruit upon	38
Science, Application to Australian Pri-	
mary Industry of	135
Scientific Method	169
Settlement of Returned Soldiers ..	148, 152
Simmonds, H. W.—	
The Effect of the Host Fruit upon the	
Scale <i>Aonidiella aurantii</i> Mask, in	
Relation to its Parasite <i>Comperiella</i>	
<i>bifasciata</i> How.	38
Smith, W. P. Cass—	
Some Aspects of Plant Pathology in	
Western Australia	93
Solution Culture, Copper Deficiency	
Symptoms of Citrus in	176
Soil Conservation, American Methods ..	184
Stem Disease of Flax, Phoma	129
Stewart, A. M.—	
Research and the Future of Wool ..	69
Stripper, Invention	41
Summer-Rainfall Pastures in Cattle	
Industries	25
Summerville, W. A. T.—	
Doctorate Conferred	183
Some Aspects of the Horticultural	
Development of Queensland	57
Surveys for Potential Land Use	20
Sutton, G. L.—	
Invention of the Stripper	41
T	
Taylor, J. K.—	
Surveys for Potential Land Use	20
Tasmanian Branch of A.I.A.S.	133
Technical Efficiency in the Rural Indus-	
tries	45
Technical Notes	38, 76, 129, 175
Trout, S. A., and Hall, E. G.—	
Some Effects of Waxing on Weight	
Loss from Oranges and Certain	
Vegetables	80
Trumble, H. C.—	
Scientific Method	169
Tryon, H. (Obituary)	44

	Page.		Page.
V		Western Australian Branch of A.I.A.S.	
Varietal Resistance of Beans to Halo			85, 134, 181
Blight	76	" " " Report to Rural	
Vegetables, Preservation of by Quick		Reconstruction	1
Freezing	114	Commission ..	
Vegetables, Effects of Waxing on Weight			
Loss from	80	Wheat Growing, Economic Factors Pre-	
Victoria, War Agricultural Committees		venting Change in	140
in	86	White, N. H.—	
Victorian Branch of A.I.A.S., 40, 84, 133, 181		The Generic Names of Bacterial Plant	
		Pathogens	78
		and Raphael, T. D.—	
		Varietal Resistance to Halo Blight in	
		Beans	76 ¹¹
W		Willoughby, W. M.—	
Wade, G. C.—		Factors Affecting the Efficient Produc-	
Production of Copper Deficiency Symp-		tion of Supplementary Pasturage and	
toms of Citrus in Solution Culture ..	177	Fodder under Partial Irrigation	157
Wales, Agricultural Education in	6	Irrigation and the Wool Industry	102
War Agricultural Committees in Victoria	86		
Waxing, Effects on Oranges and Veget-		Wool Classing and Resolving Power of	
ables	80	Eye	175
Western Australia, Agricultural Educa-		" Industry, Irrigation and the	102
tion in	1	" Research and the Future of .. 69, 108	
" " Some Aspects of		World Food Situation	137
Plant Pathology			
in	93		

16. Lyon, A. V., and Tisdall, A. L. : Coun. Sci. Ind. Res. (Aust.) Bul. 149.
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Climatic Aspects of the Bradfield Scheme

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Considerable publicity is being given at present to a scheme for "watering inland Australia" proposed by the late Dr. Bradfield.^(1, 2) Bradfield suggested the construction of large reservoirs in the interior of the continent to catch the occasional flood waters of the inland rivers, and the construction of tunnels through the Queensland ranges so that some of the eastward flowing streams could be made to flow west into Cooper's Creek and finally into an inland reservoir. He stated that such reservoirs would allow the irrigation of a great deal of valuable land in the, at present, useless interior of the continent; and, further, that the evaporation from reservoirs and irrigated land would increase the rainfall of the arid interior. The popular appeal of the Bradfield scheme is based largely on the hope of climatic improvement, so it seems wise to examine this as carefully as possible.

A substantial improvement in the rainfall of inland Australia would be of such value that it would justify the high cost of Bradfield's scheme—about £40,000,000. But it seems in the highest degree unlikely that any measurable improvement would take place. As stated by Bradfield, the argument is deceptively simple. "The evaporation—100 inches per annum—from such a water surface (20,000 square miles) could cause a fall of rain of 4 inches over 500,000 square miles of the dry inland." But such simple arithmetic is not applicable to the production of rainfall. Humidity is only one of many factors concerned in precipitation, and the presence of desert areas bordering large natural sheets of water, such as the Gulf of California and the Red Sea, is a clear indication that an abundant supply of atmospheric moisture is not in itself sufficient to cause rainfall.

It is not possible, of course, to produce rain simply by increasing evaporation. For the production of any significant fall of rain, a strong rising air current is needed. This carries the air high enough to bring the temperature below dew point, and also supplies a constant indraught of fresh moist air. The only ways in which added evaporation could increase the local rainfall are therefore (1) if such evaporation caused rising air currents, and (2) if rising air currents due to other meteorological causes were significantly increased in moisture content by such evaporation.

The Causes of Rising Air Currents.

Rising air currents are normally the result of a topographic barrier such as a mountain range, a meteorological barrier such as the cold air mass following the centre of a low pressure, or a condition of instability of the air in which any slight local disturbance initiates an extensive upward movement. Obviously, evaporation could cause rising air currents only if it contributed to instability.

Instability in air masses may be due to the distribution vertically of either temperature or moisture. In the first type, a steep lapse rate is necessary—that is, temperature near the surface must be unduly high in comparison with temperatures at greater altitudes. Evaporation, with its cooling effect on the lower layers of the air, would certainly not contribute to this condition. The second type, “convective” instability due to moisture distribution, may however be caused by the passage of an air mass over evaporating areas since it is favoured by a high concentration of water vapour near the surface. (On elevation to an altitude where dew point is reached, the lower layers of the air mass are warmed more by latent heat than the upper, and the lapse rate becomes steeper until the air is unstable by reason of temperature distribution.)

It is not possible to measure accurately the importance of this factor in producing thunderstorm rains in inland Australia, but Treloar⁽³⁾ has given three reasons why it is not likely to be significant.* In the first place, the cooling effect of evaporation on the lower levels of the air mass neutralizes the rise in temperature due to additional latent heat. Secondly, convective instability is released in an air mass only when condensation begins. Due to the low relative humidities usual in the interior, the condensation height is very great—probably about 5,000 feet in the summer. Very considerable elevation would then be necessary before any instability due to evaporation could take effect. Finally, examination of charts shows that inland falls of rain never appear to be confined to the neighbourhood of the lakes, as would be the case if evaporation from the lakes caused thunderstorm rainfall.

The importance of this factor could be measured by careful work on the number of rain days—or, better, falls of rain—in a certain area before and after the introduction of added evaporation. Long records would be necessary for statistical purposes, since the inland rainfalls are notoriously erratic, and no such information is at present available.

The Effect of Local Evaporation on the Humidity of Air Masses.

The question as to whether local sources of moisture would affect the precipitation from rising air currents has been examined in detail by Holzman.⁽⁴⁾ He quotes many writers who hold the opinion that the greater part of continental precipitation is derived from continental evaporation, but he shows very convincingly that modern meteorological research disproves this. Air masses from which rain falls are almost always of maritime origin, and continental evaporation is absorbed by dry air masses which pass out to sea without precipitating their moisture. If we remember that the rain which falls in inland Australia is derived from air masses which have as their source region either the tropical seas or the Southern Ocean, it becomes absurd to think that evaporation from an inland reservoir would have an appreciable effect. Treloar has made some calculations as to the maximum effect which could be produced in inland Australia by local evaporation. His final conclusions are that “evaporated moisture from the proposed water storages or irrigation areas would contribute insignificant additional rain to adjacent areas”.

* The writer was very much assisted in this work by the opportunity for discussion with Wing-Commander Treloar, Assistant Director (Technical), Commonwealth Meteorological Bureau, and Mr. Foley, Supervising Meteorologist, Climatological Section, Commonwealth Weather Bureau, who have been investigating the climatic aspects of the Bradfield scheme.

Evidence from Rainfall Records.

From the theoretical point of view, it seems unlikely that the dams proposed by Bradfield would affect the inland rainfall. It remains to be seen whether there is any actual evidence of rainfall improvement after irrigation. Bradfield bases his meteorological claims on two papers by Quayle^(6, 7) on the effect of water surfaces on rainfall. Quayle deals with the rainfall of certain areas in the north of Victoria preceding and following irrigation, and he claims that the rainfall to the south-east of irrigation areas was relatively increased by 5 per cent. and 7 per cent. in the two decades following irrigation, as compared with more distant stations not under the influence of increased evaporation.

Foley⁽³⁾ has shown that, in the first place, such small differences are quite insignificant compared with the high natural variability of the rainfall in this area. Further, he has continued Quayle's analysis up to 1943, using the average of all years as the standard for comparison, since the decade 1885-94 used by Quayle was abnormal in many respects. In two later decades, some of the "favoured" stations were relatively worse off than the "unfavoured". Figures are given also for Ballarat and Bendigo, and a result similar to Quayle's is obtained in favour of Ballarat. Since cultivation or irrigation cannot be the cause of this, it is evident that the small differences shown by Quayle cannot be due to the effect of local evaporation. Leeper,⁽⁵⁾ in a critical comment on the Bradfield scheme, has also shown that recent rainfall figures do not support the theory that rainfall in Victoria has been increased by irrigation.

Further work by Quayle on the effect on rainfall of Spencer Gulf and the inland lakes is also criticized by Foley. Evidence is given to show that the rainfall differences between the east and west shores of Spencer Gulf are more to be attributed to the highlands than to evaporation from the Gulf. The rainfall of inland areas is too variable for any conclusions to be based on the few figures available, but increases said by Quayle to be due to evaporation from the lakes appear to be part of a widespread rainfall trend and therefore due to other causes.

The spread of cultivation and irrigation in Victoria has been so great that it is difficult to isolate areas which might have benefited from increased evaporation from "unaffected" areas. For this reason, Murrumbidgee Irrigation Area appeared a more suitable region for a further test of the influence, if any, of irrigation on rainfall. A control ring of stations about 50 miles from the irrigated area was taken as a check on any rainfall variation not caused by irrigation. The stations were Coolamon, Narua, Yarran, Urana, Yanco, Steam Plains, Burrabogie, Eurugabah, Hillston, Lake Cargellico, Buddigower. Continuous records were available in most cases from 1890, and the few missing records were obtained by averaging the figures of the two neighbouring stations for the particular year, having first determined by graphs that the fluctuations were related. Curves were then fitted to these records by statistical methods, and the results showed that there was no significant trend in rainfall in the area over the period considered.*

Irrigation started in the area in 1912, and the amount of land irrigated increased rapidly until 1923, when it was 119,600 acres (Commonwealth Year Book). Since then there has been little change. Eight stations close to the irrigated area were chosen with records extending back in most cases to 1890—Narrandera, Uroly, Billinbah, Gogeldrie, Whitton, Rockleigh Binya, Merribee, Lake Midgeon. The average rainfall for the period up to 1912 was taken as representing the rainfall before irrigation, and this was compared in each case with the average rainfall for the period 1923-43.

* The statistical analysis of the rainfall figures is the work of Mr. E. A. Cornish, Officer in Charge, Section of Mathematical Statistics, C.S.I.R., to whom I am greatly indebted.

TABLE I.
Comparison of Average Rainfalls Before and After Irrigation.

Station.	Average, 1890-1912.	Average, 1923-1943.	Difference.	Standard Error Difference.	Ratio Diff./S.E. Difference.
	Inches.	Inches.	Inches.		
Billinbah	16.40	14.30	-2.10	1.3210	1.59
Gogeldrie	14.59	15.83	+1.24	1.3520	0.92
L. Midgeon	14.23	15.91	+1.68	1.4381	1.17
Merribee	15.21	13.48	-1.73	1.3454	1.29
Narrandera	16.91	17.03	+0.12	1.5100	0.08
Uroly	16.00	14.58	-1.42	1.4625	0.97
Whitton.. ..	15.88	15.11	-0.77	1.5617	0.49
Rockleigh-Binya ..	15.90	16.30	+0.40	1.5146	0.26

The rainfall of the district is erratic, with a coefficient of variability of about 29 per cent. For this reason, even if the rainfall had been slightly increased by irrigation, it would not be possible to prove it in the short space of 20 years for which records are available. But Table I shows that it is extremely unlikely that irrigation has had any effect on the rainfall of the area. In four out of the eight stations, the mean rainfall after irrigation is, in fact, less than the mean before—the position of these stations being quite erratic with respect to the irrigated area. But none of these differences is significant. For the difference between the averages before and after irrigation to be significant, it would have to be at least twice its standard error, and Table I shows that this is not the case with any of the stations.

There appears, then, to be no reliable evidence in support of Bradfield's promised rainfall increase, and theoretically such an increase seems extremely unlikely. In considerations of the Bradfield scheme, therefore, it would be unwise to count on any improvement in the climate of inland Australia.

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Scientific Method*

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Current attitudes to everyday problems and the methods adopted in attacking them provide a fit subject for contemplation in these times. There is an increasing consciousness of the fact that we are living in an age of science, and that scientific method requires constantly to be employed in our researches.

One has become increasingly aware, however, that communities throughout the world employ only to a limited extent the spirit and the method of science. Science, or what passes for it, is now applied to the production of almost every commodity we handle, yet few people really know how scientific work has affected and is affecting their lives. The progress of the war has witnessed an extraordinary expansion in its use for destructive purposes; but we have still to witness its employment for reconstruction, particularly in education, which is basic to the future development of intellect, of culture and of personal satisfaction in living.

Nature of Scientific Method.

People probably disagree somewhat in their definition of science, but it is the state or fact of knowing. It grew out of philosophy and logic and has developed by observation as a result of the use of the ordinary human senses. It is knowledge most particularly of Nature, and it originated in the recognition of natural happenings. Reflection and interpretation naturally followed these observations and in order to prove or disprove the explanations that arose, individuals began experimentally to test their beliefs.

For many ages all that man had was the possession of his natural senses, but as he came to make tools and then instruments, he learnt to improve his powers of observation. The introduction of the principle of measurement was the first major step in the direction of accuracy and the first cardinal necessity of any scientific work today is the accurate measurement of the observations that are made. Possibly the vast development of the means of scientific measurement, the strengthening and sharpening of our capacity for observation by scientific training, have resulted in a bias away from Nature, and science has come to be specialized, compacted and synthetic. There have been the terms 'natural science' and 'physical science' in the past. Did that imply that physical science was not natural?

Attached to the word 'science' is the term 'method', which may be defined as an orderly, logical and effective procedure for attaining an objective, which usually takes place through an arranged sequence of steps. The method may be abstract or concrete. It can be applied to research, teaching, to the treatment of a disease, or in fact to the solution of any abstract or practical problem. The opposite to methodical is, of course, something confused and disordered, and if it is very unmethodical it may become completely chaotic.

Scientific method then would be a scientific way of going about things which is essentially orderly, logical and effective, based on accurate observation, reasoned interpretation and in fact, plenty of ordinary common sense. More important still it accepts the principle that the interpretations arising from observation require to be proved by accurately conducted experiments, and that once they have been

* An address to the 49th annual conference of the South Australian Teachers' Union, 15th May, 1944.

substantiated under a sufficient range of conditions they may be raised to principles of wide generality. Freedom from prejudice and to a lesser extent from bias, is most essential.

Prejudice is probably the greatest danger to be avoided in adopting a proper scientific method. Prejudice consists in a premature judgment or acceptance of a belief on insufficient evidence, this premature judgment being held as a final solution. It is frequently found that people who know least about a matter are most ready to deliver judgment. As more is known and different viewpoints are recognized, it becomes more difficult to form a final clear-cut opinion. The greatest barrier to the utilization of scientific knowledge for human welfare is the very prejudice which ignorance, isolation and indifference all tend to foster.

One can set against this the detached spirit of science which is unwilling to accept an interpretation unless it is proven or justified, so long as either is possible. It insists on a foundation of personal experience and refuses to generalize from insufficient data. It also requires that all relevant facts should be taken into consideration.

In the words of J. M. Barrie (Rectorial address, St. Andrews University, 1922), "Science is the surest means of teaching you how to know what you mean when you say". It should train one to rely more upon principle than on facts or details, on learning rather than on set teaching. Erudition should be followed and not pedantry. One does not use the word 'system'. It suggests something fixed and empirical, whereas it is known that Nature is something fluid and elastic; and only a principle of generality can be fitted to the extraordinary amount of change to be found in Nature.

Application of Science.

Sir William Bragg (*Science in Schools*, National Union of Teachers, 1937) has stated that Nature plays an infinite number of variations on a small number of themes. There is a wealth of detail within the range that can be covered at present and an infinite amount beyond it; but there are principles of wide application which group the details together and put them within one's grasp. Perhaps one of the most universal of these is the principle of the conservation of energy which applies in all physical, chemical and biological work and many of their linkages. If this principle were recognized by everybody, there would be nobody left to be taken in by schemes involving perpetual motion or which maintain that something can be obtained for nothing.

In our work in agricultural science, we have come more and more to rely on Nature as a constant source of reference, or a means of ensuring that our procedures are sound. This does not mean, however, that one does not attempt to improve upon Nature; and the scientific approach to agriculture might be described as an attempt to enhance in detail the basic framework of Nature for the general benefit of civilized humanity. The notion that Nature is always perfect is entirely false and the outcries in terms of 'back to Nature' are far more likely to be calls to regress than to progress. A cultivated garden left to Nature first becomes a mass of weeds and finally returns to a primitive condition of some sort.

Some of Wordsworth's lines emphasize the dependence of human qualities on an appreciation of Nature and these are perhaps more significant today than when they were written. The dangers of science have become most pressing where science has moved furthest from Nature. Scientific progress and knowledge have advanced far ahead of their social utilization; and improvements in human nature do not appear to have kept pace with the increasing knowledge and control of human beings over Nature.

There is probably no danger in knowing too much about science. The chief difficulty may be that as more has come to be known about one thing, so less has

naturally become known about the vast multitude of other things, some of them far more important than that about which specialized knowledge has enabled so much to be learned. In an attempt to enable more people to learn the practical results of science, what is known as 'popular science' has developed. This is far removed from true science, because results have been stressed instead of principles; and either something of the 'magical' type or what amounts to a series of purely practical or empirical hints have been served to enthusiasts under this head. Nothing of the spirit of science or the scientific method is given under its terms. Perhaps the most important attribute of science is that it provides for vision, without which a people must be expected to perish.

Development of Scientific Method.

If we go back to the time which existed long before the earliest records of humanity some 6,000 years ago, we are inclined to believe that the first human approaches to Nature could hardly be termed scientific. It is more probable that discoveries arose by accident, coincidence and instinctive reaction. Studies of highly primitive communities indicate that this must have been so. Practices have arisen because they have worked, and these practices have then taken on the form of rites or standard procedures. There was not much room for any initiative or original and creative thought. There did, however, tend to be two divergent forms of progress. One, the rise of the philosopher resulting from the development of reason and imagination, the other that of the craftsman who developed the work of his hands. Separation was made absolute in Greece and there has been for centuries and still exists today, a cleavage in many people's minds between the work of the 'theorist', as he is called, and the work of the 'practical man'. With the rise of mathematics, physics and chemistry, this separation has tended to lessen, particularly as scientific principles have become more and more applied to practical and material ends. But this has not yet happened in biology, which is the subject that most concerns our own human happiness and sufferings, because we ourselves are living organisms and not mechanical robots on the one hand or synthesized chemical compounds, readily expressed in terms of formulæ on the other. This may be because the rise of biology had followed much later than those of the more material sciences and because also it is so very complex and unpredictable at times, that it cannot be treated in the precise mechanical terms that the other aspects of science can. But the development of education, medicine, agriculture and sociology is now so vitally dependent on biological interpretation, with which each is necessarily interwoven, that an understanding of biological principle has become prerequisite for a general education.

The absence of scientific method in the approach to biological problems has tended to emphasize history as a guide to social behaviour. History supplies evidence of past happenings which can be sifted with a view to determining causes of major happenings and effects. It provides a key to an understanding of past mistakes and also a basis for the avoidance of these mistakes in the future. It cannot, however, experimentally test and verify its consequences nor can it predict what is likely to happen in a world so largely changed by science that conditions obtain which have never been experienced before.

Many people now believe that the whole of human society is passing through a major transformation, the material basis of which has progressed so rapidly as to be bewildering to the individual. Science has provided the opportunity for placing food, work, security and freedom within reach of everybody; but there is still universal strife and a good deal of misery. Irritation has frequently been expressed at the scientist's leisurely and secluded search after minute and remote things when the world is being bombed to pieces as a result of the very inventions of science. This has naturally followed the popular conception of science as wizardry and the failure on the part of the majority to understand what science is all about. Few

people have realized how highly specialized invention has altered our lives. Many perhaps, in their school-days, grew tired of listening to the beauties or mysteries of the universe or of Nature, and have never been taught to appreciate the significance of science to human beings living in a rapidly changing world.

Blackwelder (*Science*, 2416 : 359-366, 1941) has pointed out that the critical testing of ideas, which the scientist employs automatically, is difficult for the average man to adopt ; it is much easier to be merely logical than to divest oneself of bias. Courage and a rejection of false pride are required in seeking opposing rather than supporting evidence. Speculation tends to be an ingrained habit among us all ; and if emotion overshadows the intellect, clear thinking becomes difficult. Prejudice may then dominate both thought and action. If scientific method is followed as a habit, it becomes possible to secure the admonition of Solomon to "get understanding", and so avoid the dogma which has been and still is the fashion even among a great many scientists.

A proper scientific attitude was shown by Darwin, who said regarding the storm of criticism which raged about *The Origin of Species*—"If my book cannot stand the bombardment, why then, let it go down and be forgotten".

Science and Education.

We must ask ourselves whether our educational systems really fit people for a scientific approach to the practical needs of life. It seems that in the perfervid rush to secure degrees, diplomas and certificates, a good deal has been forgotten about the worthiness of producing citizens who are able themselves to gain satisfaction out of life, and at the same time assist their fellow citizens to do likewise.

Until 20 years ago, it was thought that the development of science led automatically to a better world. Today, however, there has developed a widespread sense of perplexity, especially among the younger people, which has temporarily been submerged by the excitement and regimentation associated with war. But what of when the war ends ? Unless some objective can be held out and gratification within the mind developed there is bound to be chaos. Scientific understanding, biological understanding and the unlimited opportunity for satisfaction in personal discovery from day to day, seems to be the only guarantee of general human betterment.

It is unwise to consider the attributes of science without due reference to the humanities ; and we require to avoid canalization into pure lines of thought or investigation. Specialization did not lead to the origins of science as we know it. A most elementary reading of its history will show that both the drive that led to scientific discovery and the means by which those discoveries were made were directed towards an understanding of natural phenomena or the attainment of material ends. Specialization only developed with the necessity to proceed further along highly selective lines in order to establish new knowledge. The drive that activates the specialized researcher is this desire to contribute something fresh. But when we consider the case of the ordinary citizen who requires to be educated, we must see that he is equipped sensibly at all main points and is not merely an assembly of unrelated parts.

Bragg (*loc. cit.*) pointed out that there are two main sides to science—the utilitarian and the cultural, but that there is no sharp boundary between the two and that the utilitarian side obviously merges into the cultural. Thus there could be developed a greater appreciation of scientific principle in matters of public opinion, and especially in such important national concerns as nutrition, health, production, planning and the economic development and conservation of resources. Again, this could only result in the suppression of pseudo-scientific arguments that one still sees every day in propaganda and advertising of the quack type. In a discerning report of the Science Masters' Association of Great Britain (*Teaching of General*

Science, London, 1936-38) it is stated that nobody can be regarded as truly cultured if he has never had his imagination stirred by the great adventure of ideas which constitutes the scientific exploration of natural phenomena; and of all the claims made for the inclusion of general science in school curricula, the strongest undoubtedly is that which stresses the cultural value the subject possesses.

Science and Society.

Bernal, in his recent book *The Social Function of Science*, concludes that "we have in the practice of science the prototype for all human common action. The task which scientists have undertaken—the understanding and control of Nature and of man himself—is merely the conscious expression of the task of human society. It is by these methods that humanity is most likely to secure its own future."

A scientific system can only be fully utilized if infused into a culture whose method of approach is also logical, intelligent, based on high moral principle and high humanitarian motives, and which leaves room also for some adventure and romance. The standards and general level of culture a community possesses arise from the main ties that bind it together; and the extension of culture through different communities is surely the most likely means of cementing them. We need it to thread the states of Australia closer and we need it also to associate ourselves more closely with other countries.

Many people have feared that the extended use of science in the future would result in a chemically purified society from which ordinary enjoyments and pleasures would be absent. These fears are groundless, because science has come now to realize the innate complexity of natural processes; but it is humanly impossible to measure all the innumerable facets and their connections which enter into the network or web we know as life.

A wireless talk was given a little while ago by a miner in England. He said he wanted a new approach to life, more novelty, and opportunity for adventures of the mind. He found that today's approach to work with its monotony, system and mathematical prediction made everything so uninteresting that actually nothing ever happened. He said that we have had freedom, but not freedom to use freedom. We are forgetting how to play and are discouraged from doing things for ourselves by the rise of professionalism. Freedom and responsibility go hand in hand. If we have more curiosity and are encouraged to ask more questions, personal discoveries from day to day can be a major occupation and interest for everybody. This envisages a type of education that would make use of the natural human desire to understand, and might encourage more people to develop the ability to think for themselves.

Cooperation is required more and more to replace antagonism, both between individuals and between communities. Ignorance and jealousy are two of the most fertile contributors to prejudice and can only be substantially lessened if there is an acknowledged partnership between youth and experience as well as between science and culture. To achieve these may take much courage; but courage can achieve much if there is singleness of purpose.

There has probably been insufficient appreciation of how much change is a necessary part of life as it is of most things that influence life. We are all accustomed to the extraordinary vagaries of the weather, to changes in the sky and on the ground, in our gardens and fields throughout the year and over the years; and there are the changes in our own daily attitude and temperament according to the weather or to all sorts of psychological influences, personal and in the mass.

The relatively uniform conditions of tropical climates, with their restricted opportunities for physical contrast and stimulation, inevitably discourage civilized progress by their very monotony. Variability provides the underlying causes of physiological rhythm and of all living processes. The charm of the oasis, less

attractive in itself than ordinary tropical scenery, lies in the contrast it offers to the surrounding barren wastes of the desert.

A most distinctive quality of our present civilization is its constant subjection to far-reaching changes. Science has shown that the ideal should be one of progress rather than of stability and the penalty for failure to progress in a modern world must be stagnation.

The classical education of the past century suited the stable environment of European centres, but this is now out of harmony with the present world setting. A recent agricultural analysis conducted in Britain revealed a pride of ignorance of science as it has existed up to now, and contempt also for manual skill because it has been unrelated to any culture. This attitude, because of its ignorance of scientific method and achievement completely disallows a perception of change as a basic need of life, and the close association of both Nature and science with change. It is therefore unable to assess present and future trends with accuracy.

The value of the scientific attitude in this connection is that it affords guidance based on thoroughly tried principles in situations of a highly complex nature and which involve constantly varying factors. It offers adjustment, elasticity and adaptation as alternatives to the use of fixed laws based on the conception of a single variable which can be manipulated at will.

The application of scientific method to agricultural problems involves an analysis of all the available facts and the construction of a somewhat resilient basic pattern along which future developments should proceed. Analyses require to be of a quantitative character, firstly in the form of observation, secondly in the form of research; and the researches need to be closely linked with practical endeavour. Many advances that have arisen in this way have now been tested on a sufficiently large scale to demonstrate that widespread implementation of the principles involved can be efficiently undertaken; and it is now time that these facts, many of which have come to be learned only recently, were made known throughout the community. But it is not sufficient to have them known only as facts. Before they can be appreciated in full, a more general adoption of scientific methods of approach is required, and this to a large extent is in the hands of teachers.

Teaching of Science.

The teacher should remember that no two pupils are alike, and that each will learn most from his own curiosity and observation, which will depend much upon the innate desire to be informed; that so long as undue emphasis is placed on memory and the subject matter is unreal, the pupil is likely to remain uninterested; that enquiry on the part of the student is the teacher's greatest asset; that the surest way of attaining knowledge is through analysis by the student himself, using scientific method; that the inculcation of this method is basic, and that guidance rather than control by the teacher is the thing; that the student should be helped to maintain the picture of his problem in mind and make analogies which will lead to an emphasis on general relations or principles; that he should be encouraged to make intelligent guesses, but to maintain a state of doubt or suspended conclusion until experimental verification has been obtained.

These are some hopeful trends in the directions outlined, and the soldier of the ranks today has already in him much of the officer. Let us hope that he can always say with Henley that he is largely, at any rate, the master of his own fate.

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TECHNICAL NOTES

THE RESOLVING POWER OF THE EYE AND THE CLASSING OF WOOL.

In the classing of wool it is generally assumed that there is a close correlation between crimp and mean diameter, an assumption not supported by research.^(1, 3) In recent months many wool experts have maintained that they are not influenced by the crimp but are able to detect without difficulty small differences in fibre diameter and hence quality number. This contention implies an ability to distinguish between mean diameters of the order of 18, 20, 22 and 24 microns, etc. The expert must also be capable of selecting fibres which are near the mean value of fibre thickness and this in itself is difficult, for the range of fibre-diameter distribution may vary from 14 microns upwards and the human eye is readily attracted by the coarser fibres. Moreover, varying quantities of yolk—the products of the sebaceous and sudoriferous glands associated with the wool follicle—cause varying apparent diameters in wools of the same real diameter. Helmholtz is frequently quoted as observing that the minimum angle of resolution for the human eye is one minute of arc, a limitation imposed by the size of the nerve endings in the retina.⁽²⁾ It is held that images from two different objects falling on the same nerve ending could not be distinguished as separate. For the normal eye, the "least distance of distinct vision" is about 25 cms. The angle of one minute of arc subtended at the eye by an object 25 cms. away represents an object size of 75 microns. This would preclude the use of diameter estimations in assessing the Australian clip, as very few fibres exceed 75 microns diameter. Distinctions between quality numbers on fibre diameter alone would be completely impossible.

With a view to closer examination of this matter, ten fibres were mounted in the clean state on a black background, with the fibre crimp just removed by tension. These were submitted to thirteen observers, including woolclassers, textile technologists and laymen, who were asked to place them in order of fibre diameter. There was a general agreement between the results of all observers, and a summary of their judgments is given. The diameters of the mounted fibres were measured *in situ*.

- (a) Fibres over 40 microns apart in fibre diameter were distinguished readily by all observers.
- (b) The lower limit for the majority of observers was 15-20 microns difference in diameter. This represents approximately 15 seconds of arc at 25 cms.
- (c) These discriminations could only be made against a black background. With any other background, only the coarser fibres (60-35 microns) were clearly apparent.

It is suggested that claims that the wool expert can discriminate the finer distinctions of quality number by reference to fibre diameter alone are ill-founded, and furthermore that the Helmholtz figure of a resolving power of 1 minute of arc is high when applied to single wool fibres on a black background.

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PRODUCTION OF COPPER DEFICIENCY SYMPTOMS OF CITRUS IN SOLUTION CULTURE.

Dieback or exanthema of citrus has been known for a considerable time and was first described on the orange in Florida by Fowler⁽⁵⁾ in 1875, and has since been found in most citrus-growing areas of the world.

In articles written in 1913 and 1917, Floyd^(3, 4) stated that copper sulphate applied to the soil, or Bordeaux mixture sprayed on the leaves, cured the condition, but he did not suggest that copper deficiency was the cause. At that time the importance of the so-called minor elements was not realised.

In 1934 Fudge⁽⁶⁾ reported that copper, used as a soil dressing or a spray, controlled exanthema, and in 1935 Haas and Quayle⁽⁷⁾ showed that leaves of exanthema affected trees were low in copper. It has therefore been well established that exanthema is caused by copper deficiency, but as far as the author is aware, the symptoms have not been previously produced experimentally by growing the plants in a copper-deficient medium. However, Haas⁽⁸⁾ and Chapman *et al.*⁽²⁾ have succeeded in producing zinc deficiency symptoms of citrus in solution culture.

An experiment was therefore conducted at Burnley with the object of producing copper deficiency symptoms in solution culture.

Methods.

The solution used was that of Arnon⁽¹⁾ and the main constituents were purified by Stout and Arnon's⁽¹²⁾ modification of Steinberg's⁽¹¹⁾ method. The solutions were tested for heavy metals by the dithizone method, and found to be within the limits set by Stout and Arnon.⁽¹²⁾ Double distilled water, produced in a pyrex glass still, was used in preparing the solutions. All the heavy metals, except iron, known to be important for plant growth were added to one series, while the same heavy metals, except copper and iron, were added to the other series. Iron was added to all culture solutions at weekly intervals, in the form of a 0.5 per cent. ferrous sulphate, plus 0.4 per cent. tartaric acid solution; 0.6 ml. was added per litre.

The plants were grown in two litre pyrex beakers which were blackened on the outside. The tops of the beakers were covered with plaster-of-Paris tops, coated with paraffin. The beakers and the plaster-of-Paris tops were washed with A.R. hydrochloric acid and then rinsed several times with double distilled water. The cultures were aerated continuously with air filtered through caustic soda solution, dilute hydrochloric acid, double distilled water and cotton wool. The solutions were changed at six to eight week intervals.

The plants used were raised from Valencia orange seeds in acid-washed sand. As soon as the plants were well established the cotyledons were removed and the plants transferred to the culture solutions. Haas⁽³⁾ and Chapman *et al.*⁽²⁾ used citrus cuttings, raised in washed sand, for their experiments.

Results.

The plants grown on the copper-deficient solution grew much less rapidly than those on the complete solution, and the internodes were shorter than normal (Figure 1). Millikan⁽⁹⁾ noted that copper deficiency causes a shortening of the internodes of flax. After about eight weeks, the terminal shoot developed into a multiple bud of the type described for exanthema under field conditions.^(3, 4, 6) Each multiple bud consisted of a cluster of ten to twenty buds. After the development of the multiple buds the plants made little further growth.

Concurrently with the development of multiple buds the youngest leaves developed an irregular pale green mottling, though the older leaves remained dark green (Figure 2). Mottling of the foliage is not described in most of the literature relating to exanthema, though Orth *et al.*⁽¹⁰⁾ describe a type of chlorosis of the leaves of citrus trees, which is cured by dressing the soil with copper sulphate.



Figure 1 (above).
Growth of Valencia orange seedlings in copper-deficient solution compared with that in complete solution. Note the short internodes on the copper-deficient plants.

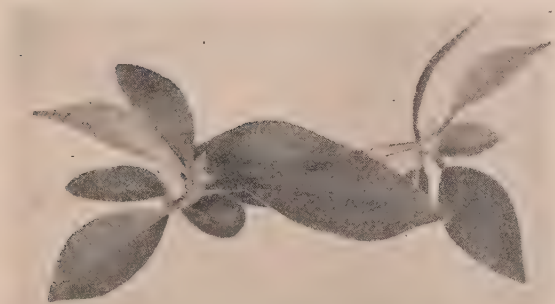


Figure 2 (at left).
Copper-deficient plants showing multiple buds and mottling on the young leaves.

The root growth on the copper-deficient plants was very much reduced and the lateral roots usually only grew to a length of about half an inch, as compared with lateral roots several inches long on the plants grown in complete solution.

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The Australian Institute of Agricultural Science

SEVENTH GENERAL MEETING.

The programme and Agenda of the Seventh General Meeting, to be held at the School of Agriculture, the University, Melbourne, 12th-15th February, 1945, has been arranged as follows :

Programme.

Monday, 12th February, 1945—

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|-----------|----|----|----|---|
| 2.00 p.m. | .. | .. | .. | Council meeting. |
| 7.00 p.m. | .. | .. | .. | Official Dinner arranged by Victorian Branch. |

Tuesday, 13th February, 1945—

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|----------------------|----|----|-----------------------|-----------------------|
| 9.30 a.m.-12.45 p.m. | .. | .. | } Institute Business. | |
| 2.00 p.m.- 5.00 p.m. | .. | .. | | |
| 8.00 p.m. | .. | .. | .. | Presidential Address. |

Wednesday, 14th February, 1945—

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|----------------------|----|----|--|
| 9.30 a.m.-12.45 p.m. | .. | .. | } Discussion : The Post-War Structure of Agriculture in Australia. |
| 2.00 p.m.- 5.00 p.m. | .. | .. | |

Thursday, 15th February, 1945—

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|----------------------|----|----|-------------------------|-------------------------------------|
| 9.30 a.m.-12.45 p.m. | .. | .. | } Discussion continued. | |
| 2.00 p.m.- 5.00 p.m. | .. | .. | | |
| 5.00 p.m. | .. | .. | .. | Installation of Incoming President. |

Friday, 16th February, 1945— Council Meeting.

Agenda.

1. Institute Business, Tuesday, 13th February, 9.30 a.m.

- (1) Minutes of Sixth General Meeting.
- (2) (a) Report of Council on Institute Activities.
(b) Report of Editor of Journal.
(c) Report of Business Manager of Journal.
- (3) Statement of Accounts from Honorary Treasurer.
- (4) Report of Council concerning Election of President.
- (5) Other Business :
 - (a) Policy of the Institute in relation to " Objects " listed in Memorandum of Association.
 - (b) Functioning of Proxy Council.
 - (c) Rotation of Office of Management.
 - (d) Method of Election of President.
 - (e) Returned Soldier Preference.
 - (f) Salaries and Status.
 - (g) Publication of an Australian Journal of Agricultural Science.
 - (h) Qualifications for Membership.
 - (i) Provision for Life Membership.
 - (j) New Article 29a re Publication.

2. Discussion : The Post-War Structure of Australian Agriculture.

Wednesday, 14th February, 1945—

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|-----------|-----------|----|--|
| 9.30 a.m. | Session 1 | .. | Agricultural Policy in the Post-War Period—General Considerations. |
| 2.00 p.m. | .. 2 | .. | Agricultural Research to meet the Demands of Post-War Agriculture. |

Thursday, 15th February, 1945—

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|-----------|-----------|----|--|
| 9.30 a.m. | Session 3 | .. | The Organization of Agricultural Extension Services in the Post-War Period. |
| 2.00 p.m. | .. 4 | .. | The Provision of Personnel, the Co-ordination and Structure of University Courses in Agriculture, Undergraduate and Post-graduate. |

3. Installation of Incoming President, Thursday, 15th February, 1945, 5.00 p.m.

MEETING OF COUNCIL.

A Council meeting was held at the School of Agriculture, The University, Melbourne, on 18th September, 1944.

Present.—Mr. R. A. Boyle (V.), in chair, Mr. R. W. Prunster (A.C.T.), Mr. G. H. Vasey (N.S.W.), Mr. F. S. Crawford (T.), Dr. I. F. Phipps *vice* Dr. A. E. V. Richardson (S.A.), the Honorary Secretary, Mr. A. J. Vasey, and the Honorary Treasurer, Mr. R. L. Twentyman. Apologies were received from Dr. A. E. V. Richardson (S.A.), Mr. J. L. Provan (Q.) and Dr. H. C. Forster (W.A.).

Statements were received from the N.S.W. and Victorian Branches in regard to the position on returned soldier preference in those States, and were listed for discussion at the forthcoming General Meeting.

The draft report on improvement of status and salaries of members of the Institute prepared by Dr. Forster and Mr. Vasey was received, and after discussion and certain minor alterations, was approved for circulation to Council members.

The A.C.T. Branch report on "Ways and means for improving the organization of the Institute" was also listed for discussion at the General Meeting.

The following applicants were admitted to membership:—to Corporate Membership: S. T. Smith, E. H. B. Lefroy (W.A.); V. M. Lewis, K. D. McLachlan (N.S.W.); G. B. Sluiter, J. G. Bath, Miss J. A. Demaine, A. M. Acock (Vic.); O. Bowden, Miss N. T. Burbidge (S.A.); W. F. Walker (Tas.). To Student Membership: J. R. Niccol, R. W. Condon, K. J. Symes, W. F. Owen, G. K. Atkins, W. K. Single, K. E. Hutton, P. I. Pryke, Miss A. Diecks, A. B. Costin, C. R. Ford, J. R. Rayner, S. G. Burns, F. C. Butler, Miss M. A. Churchward, Miss A. M. Kingsland, D. J. McKenzie, M. R. J. Salton, B. L. Jones, G. J. Clowes (N.S.W.); R. E. Kuchel, M. B. Spurling, F. R. Humphris, J. V. Mertin (S.A.); Miss E. K. Kenny, E. W. Boehm, C. T. Gates (W.A.).

The financial statement showed a balance at bank of £304 14s. 3d., as at 18th September, 1944.

The auditor's statement of accounts, which is published on page 180, and his report, for the year ending 31st December, 1943, were received.

MEETINGS OF BRANCHES.

New South Wales Branch.

At a meeting of N.S.W. Branch on 8th September, Major M. D. Miller and Major B. L. Seabrook, of Headquarters Staff, Procurement Division of the United States Army Services of Supply, exhibited several films on the "Mechanization of Vegetable Culture". Majors Miller and Seabrook have been closely associated with Australian food-production programmes in relation to the U.S. Army and have toured Australia demonstrating the possibilities of large-scale production of vegetables by the use of modern equipment. Their background of both U.S.A. conditions and Australian problems facilitated a vigorous discussion.

At a meeting on 13th October the N.S.W. Branch adopted a Committee of Management recommendation that the General Meeting of the Institute, February, 1945, should include, in lieu of Technical Discussions and Symposia, four sessions, as follows: (1) Agricultural Policy in the Post-War Period—general considerations, (2) Agricultural Research to meet the Demands of Post-War Agriculture, (3) The Organization of Agricultural Extension Services in the Post-War Period, (4) The Provision of Personnel—the Co-ordination and Structure of University Courses in Agriculture.

The meeting also discussed the publication of a Journal of Agricultural Research. It resolved "That this Branch considers that the Institute should take the initiative in fostering the establishment of an adequate scientific journal designed to further the interests of agricultural research in Australia", and recommended that Council invite the Institute's Publications Committee to prepare a report for presentation at the General Meeting, February, 1945.

The main business of the meeting on 13th October was a discussion, opened by Dr. E. T. Edwards, on the co-ordination of agricultural research, with special reference to the establishment of research stations. The decisions of the meeting are embodied in the following resolutions:

(1) That this Branch of the Australian Institute of Agricultural Science is in favour of the establishment of agricultural research stations in N.S.W. provided that they are adequately staffed and equipped for comprehensive investigational work, but considers that the independent establishment of such stations by separate entities such as the Department of Agriculture, Soil Conservation Service, University of Sydney and the Council for Scientific and Industrial Research is not in the best interests of Agricultural Science or the community in general.

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE.

Income and Expenditure Account for Year Ended 31st December, 1943.

INCOME.

1942 £ s. d.	1943 £ s. d.		1942 £ s. d.		1943 £ s. d.	
	£	s. d.	£	s. d.	£	s. d.
146 9 4	To Cost of Journal	..	..	..	..	..
30 8 9	" Printing and Stationery	..	..	..	..	..
8 8 0	" Audit Fees	..	..	..	..	..
13 10 11	" Petty Cash and Incidentals	..	..	..	..	..
..	" Grants to Branches—	..	..	..	..	..
..	Victoria	..	..	..	..	..
24 9 6	New South Wales	..	..	..	..	..
35 15 0	South Australia	..	..	..	..	..
15 13 0	Queensland	..	..	..	..	..
13 4 0	Western Australia	..	..	..	..	..
7 11 0	Federal Capital Territory	..	..	..	..	..
3 17 0	Tasmania	..	..	..	..	..
311 1 0	Total Expenditure	..	..	..	..	..
121 7 4	" Surplus for Year	..	..	..	..	..
		£444 18 7			£444 18 7	

Balance Sheet as at 31st December, 1943.

LIABILITIES.		1942 £ s. d.		1943 £ s. d.	
£	s. d.	£	s. d.	£	s. d.
112 4 0	Sundry Creditors—	..	..	..	..
20 10 11	Branch Grants	..	..	..	..
..	General	..	..	..	..
6 6 0	Subscriptions Paid in Advance	..	..	..	..
560 13 10	Accumulated Fund at 1/1/43	..	..	..	..
121 7 4	Add Surplus for Year to 31/12/1943	..	..	..	..
		£821 2 1		£889 6 7	
ASSETS.		1942 £ s. d.		1943 £ s. d.	
£	s. d.	£	s. d.	£	s. d.
417 12 8	Cash at Bank—	..	..	..	..
8 11 5	Melbourne	..	..	..	..
..	Sydney	..	..	..	..
100 0 0	Fixed Deposit	..	..	..	..
100 0 0	Commonwealth Govt. Bond 4½% due 15/8/56	..	..	..	..
100 0 0	Commonwealth Govt. Bond 3½% due 15/11/58	..	..	..	..
100 0 0	Commonwealth Govt. Bond 3½% due 15/9/59	..	..	..	..
3 0 0	Interest Accrued	..	..	..	..
82 13 0	Subscriptions Outstanding (since collected)	..	..	..	..
9 5 0	Office Furniture	..	..	..	..
..	Petty Cash on Hand	..	..	..	..
		£821 2 1		£889 6 7	

(Sgd.) CLEVELAND, SON & HIS LOP.
Chartered Accountants (Aust.).

Printed and dated 1st September, 1944.

(2) That the Premier be informed of the need for the intensification of agricultural research and of the dangers of unco-ordinated development and that the N.S.W. Government be asked to set up an Agricultural Research Advisory Committee with a view to fostering the co-operative development of agricultural investigational work, to advise the Government on the establishment and location of research institutions and such other matters as may be considered desirable for the betterment of agriculture in this State.

(3) That the Agricultural Research Advisory Committee should include one representative from each of the following organizations: N.S.W. Department of Agriculture, Soil Conservation Service, University of Sydney, Council for Scientific and Industrial Research, The Australian Institute of Agricultural Science (N.S.W. Branch), The Australian Veterinary Association (N.S.W. Branch), The Australian National Research Council, together with one representative of the pastoral industry and one representative of the agricultural industry.

(4) That it shall be obligatory for the Advisory Committee to consult the appropriate organizations of primary producers in all cases where matters affecting their particular interests are under consideration.

(5) That the Council of the Institute be informed of these resolutions and of the action taken to bring them under the notice of the State Government, and that Council be requested to inform other branches with a view to having similar action taken in other States.

These decisions have been conveyed to the Premier of New South Wales.

South Australian Branch.

The second meeting in the series dealing with "The Use of Land Resources" was held on 15th September, when three papers were given. Dr. A. R. Callaghan spoke on "The Place of Livestock in Present-day Agriculture"; Mr. C. R. Kelly on "The Changing Scene from the Producer's Angle"; and Mr. R. I. Herriot on "Soil Conservation in Relation to Methods of Production". Papers given at the first meeting of this series have been published in *Journal of the Department of Agriculture of South Australia* (August, 1944).

Victorian Branch.

On 6th October, Mr. P. T. Mitchell, B.Agr.Sc., an officer of Commonwealth Food Control and Chairman of the Victorian Branch of the Federated Society of Technical Workers, outlined arbitration machinery and its application to the salaries and conditions of scientific workers in general and to agricultural scientists in particular. A summary of his address appears under *Current Notes and News*.

Members also attended the following meetings of the Melbourne University Agricultural Society. On 1st September, Capt. N. A. M. Kjar gave an illustrated talk on "Vegetable Production in the Australian Army". Mr. R. W. Bond, B.Sc., Acting Sales and Marketing Officer of the Victorian Forests Commission, on 20th October, spoke on "Forestry in Relation to National Development". His address was illustrated with slides and films.

Western Australian Branch.

At a general meeting on 11th August, short addresses on some technical aspects of settlement in the Kimberley areas of Western Australia were given by Mr. R. J. Dumas (Director of Works), Mr. G. K. Baron-Hay (Under-Secretary for Agriculture), Mr. A. M. Stewart (Institute of Agriculture), Dr. L. J. H. Teakle (Department of Agriculture), Mr. G. F. Melville, and Mr. C. F. H. Jenkins (Department of Agriculture). Visitors included members of the Rural Reconstruction Commission, Economics Society, Institute of Engineers, Institution of Surveyors, Institute of Veterinary Science, Pastoralists' Association and Royal Agricultural Society.

Mr. Dumas opened the discussion by indicating the position and suitability of the proposed dam site on the Ord River and giving a brief description of engineering difficulties to be overcome in its establishment. The dam would serve an area of at least 100,000 acres of easily irrigable and seemingly good quality country. To provide five acre-feet of irrigation for this area, assuming 100 per cent. irrigated, 125,000 million gallons of water would be required. Diversion works would cost £300,000 to £400,000 and would ultimately be used; in the meantime water would be pumped by hydro-electric power. Floods and silting would provide major problems.

Mr. Baron-Hay gave a brief résumé of the character of the country embraced by the irrigation project and of earlier expeditions to the Kimberleys. Land utilization to date had been entirely for cattle under range conditions and in this respect there was much room for improvement. Plants and animals only grow in the wet season, and due to this factor it takes about five years to raise a 540-lb. beast. By utilizing an irrigation area close to the Wyndham Meatworks, it is possible that this seasonal difficulty, and also that of travelling the cattle over poorly grassed stock routes just prior to slaughter, might be offset.

The area was too valuable to be neglected, but land settlement would be costly. Many problems would have to be solved in connection with crops, soils, animals and insects, and to assist in this matter, a research station to serve the northern areas should be established in co-operation with the Commonwealth and C.S.I.R.

Mr. A. M. Stewart stated that climate was the prime determinant of the potential utilization of land and proceeded to compare the Ord River with similarly situated land areas in other parts of the world. Two West African centres, Kayes on the Senegal River and Segou on the Upper Niger, have climates very similar to Wyndham, and as they are also centres of irrigation projects, their experience might prove of assistance in the establishment of our proposed scheme. The special qualifications necessary for people living in hot climates were outlined and emphasis placed on the need for periodic changes to a more stimulating climate, and that habits of living, clothing, diet and sanitation must be adapted to the environment.

Dr. L. J. H. Teakle said that soils in the region were receiving attention from two angles: (1) detailed surveys, (2) reconnaissance type of investigation, mapping the soils into groups of similar potentialities. From his own observations of the country, Dr. Teakle gave a picture of the general soil types and referred to the problems of erosion and the consequent silt load of the river.

Mr. G. F. Melville amplified Mr. Hay's remarks on stock problems and pointed out the necessity for improving the quality of stock in the area by systematic breeding.

Mr. C. F. H. Jenkins said that little detailed information could yet be offered on entomological problems due to the fact that no consistent study, especially in relation to cultivated plants, has yet been possible. Present knowledge is sufficient, however, to indicate that serious pests do occur in this region, and due regard must be given to these in any future agricultural development. Amongst the more important pests present may be cited cattle tick, buffalo fly, plague locusts, cotton boll worm, pink cotton boll worm, cotton stainer bugs, orange piercing moth, and dengue- and malaria-carrying mosquitoes.

At a general meeting on 13th October, 1944, Mr. G. H. Burvill discussed the soils of the Ord River area in greater detail. From experience gained during a soil survey of the area extending from May to September, 1944, Mr. Burvill was able to provide much interesting factual detail on the nature of the soils, and the general hydrology of the area. He stated that aerial photographs had proved of great value in the surveys, and a number of aerial photographs projected by epidiascope served to illustrate the talk and give listeners a more vivid picture of the Ord River country.

Current Notes and News

Industrial Arbitration and the Scientific Worker.

In an address to the Victorian Branch of the Institute on 6th October, 1944, P. T. Mitchell, B.Agr.Sc. (Chairman, Victorian Branch of the Federation of Scientific and Technical Workers) outlined Arbitration machinery and discussed its application to the salaries and conditions of scientific workers in general, and to agricultural scientists in particular.

Arbitration Machinery.

The Commonwealth through the Arbitration Act has established a Federal Arbitration Court to which application is made for awards by organizations registered with the court. Evidence is presented to the court by the contending parties and judgments of the court are binding on the parties concerned. Penalties are prescribed for non-compliance with determinations of the court. Industrial Agreements reached between registered employees' organizations and employers are filed with the court and are invested with the same legal force as court determinations.

The States have their own industrial machinery, which varies considerably. The majority of States have arbitration courts, but in Victoria and Tasmania legislation provides for the establishment of wages boards. Any parties may apply to the Department of Labour for the establishment of a wages board for any particular industry. A wages board usually comprises seven (7) members, consisting of three employees' representatives, three employer representatives, and a chairman appointed by the Government. The determinations of wages boards are enforced by the State Department of Labour.

In the Commonwealth Public Service, the Public Service Board (P.S.B.) is the employers' representative. Any employees organization registered with the Federal Court may apply to the P.S. Arbitrator for awards. The claims of the organization are usually contested by the P.S.B. Evidence may be presented by both parties; and the determination of the arbitrator is binding, and filed with the Federal court. Agreements reached between an employees organization and the P.S.B. are also filed with the court.

In the Victorian Public Service, the situation is very different. The Public Service Board of three (3) members, comprising one (1) employee representative and two (2) Government appointees, determines the salaries and conditions of employees. An employees organization may address written representations to the Public Service Board or ask the board to receive a deputation, but evidence may not be called as in the Federal sphere. Appeals against deter-

minations of the board may only be made to the Governor-in-Council. In other words, having failed to secure satisfaction from the employer's representative (the Public Service Board), an appeal may only be made to the employer himself—a procedure entirely different from that applying to all workers outside the State service. It follows, therefore, that the salary paid to the Victorian State employee is subject to political expediency, whereas the remuneration of workers outside the State sphere may be determined by an impartial judiciary.

Salary Comparisons.

Examination of the actual salaries paid within the Victorian Department of Agriculture reveals an astounding anomaly—the base grade for holders of a Bachelor Degree in Agricultural Science has a range of £344-£460 per annum, whereas those holding a Bachelor of Veterinary Science Degree are employed at a probationary salary of £425 per annum for four years and are then advanced to £525-£616 per annum with accrued increments. It is difficult to see how such an anomalous position could be maintained before an arbitration authority if such existed for the State service.

The salaries paid in the New South Wales Department of Agriculture are determined, where necessary, by arbitration procedure; disputes between the Professional Officers' Association and the Public Service Board being referred to a Conciliation Committee analogous to the Public Service Arbitrator (Commonwealth). The present awards for agriculture were obtained by agreement in 1939. If we compare the salary of £361-£466 paid in the base grade (Grade II) to scientific officers of the New South Wales Department with that paid in the Victorian Department, we find that superficially they are similar. However, when it is appreciated that the increment rate in N.S.W. is £25 per annum, and that passing the barrier between Grade II and the Grade I range of £494-£594 is essentially contingent on efficiency, and not on the death, retirement, or promotion of a Grade I officer, it is apparent that the New South Wales Award conditions are far more generous than the Victorian Board's determinations. Promotion to Grade I is subject to satisfactory service and to a certificate being furnished by the Under-Secretary that the officer has engaged in a definite line of original research. This requirement is, of course, peculiar to the N.S.W. Department because of its specialized type of organization. It is understood that the grade barrier is not a formidable one, officers attaining the maximum of the Grade II range usually proceeding to Grade I. In effect, the salary range open to all suitably qualified scientific workers in the N.S.W. Department is £361-£594 per annum.

The salary range in the base grade for the Victorian Department is also inferior to that of the Commonwealth Service, as shown by the Professional Officers' Association awards, which apply to all main classes of scientific workers, viz. architects, engineers, chemists, bio-chemists, and others. Although commencing salary in Victoria (£344) is similar to that of the Commonwealth (£346), the upper limit of the range for Victorian workers is £460 per annum, whereas the Commonwealth maximum is £550 per annum. The salaries paid in the senior positions under Commonwealth awards are similar to those paid in the State Department. From this comparison it is obvious that the existing awards have stabilized salaries for the base grade, in which the majority of scientific workers are employed, at a higher level than operates for workers ineligible for these awards. Further, temporary officers in the Commonwealth and N.S.W. Services are employed at the same salary levels as permanent officers.

However, the present Commonwealth awards, obtained in 1936, are not considered entirely satisfactory. The rapid expansion of the Commonwealth Service during the war has demonstrated serious anomalies in grade definition, enabling the P.S.B. to avoid the suitable classification and payment of officers above the base grade, appointed to positions in rapidly expanding establishments. As a result of these developments, considerable dissatisfaction has been expressed, and through failure of the established employee organizations to take appropriate action to remedy these and similar anomalies, the initiative was taken by temporary officers in forming an organization pledged to a progressive policy on salaries and conditions, to represent all scientific and technical workers in all fields of employment.

Doctorate Conferred.

It has recently been announced that the degree of D.Sc. has been conferred on Mr. W. A. T. Summerville, of the Queensland Department of Agriculture and Stock, by the University of Queensland for his studies on the nutrition and development of the banana plant (*Musa cavendishii* Lambert).

Dr. Summerville graduated B.Sc. in 1929 and, on an entomological thesis, obtained his M.Sc. in 1933. In 1936 and part of 1937 he made an extensive trip overseas in which he made contact with most of the agricultural research organizations in England, Canada, United States of America, Palestine, Hawaii and Ceylon. Although starting his scientific career on entomological problems, he transferred his attention to horticulture a few years after graduation, and most of his work since being stationed at Nambour has been concerned with horticulture, particularly with the banana and citrus industries. He transferred to Brisbane in 1941 and since then has been directing research into the many vegetable problems suddenly made acute by abnormal war-time production.

Although Queensland's banana output has fallen considerably in the last ten years, Dr. Summerville is a vigorous contender that banana production deserves a far better status than the nomadic occupation that it is usually considered. His studies are helping to lay the foundations for a better knowledge of the nutritional requirements of the banana plant.

Dr. Summerville was President of the Queensland Branch of the Institute last year, and has long been an active member of the Branch.

American Soil-Conservation Methods.

The following information, of particular current interest, is taken from a recent circular issued by the United States Office of War Information, Sydney.

"Fighting to reclaim once-productive crop-lands ruined by wind and erosion so disastrously that three billion tons of top-soil were once blown 2,000 miles across the nation in a day, the United States has developed soil-conservation methods that, since 1935, have salvaged about 8,000,000 acres of injured land in America's great 'Dust Bowl'.

"These methods, many of which are adaptable for use in other eroded areas, were worked out by the United States Department of Agriculture Soil Conservation Service in cooperation with American farmers. They sought not only to reclaim the land but to maintain the productivity of the soil. The Department of Agriculture discovered that some soil-stripped land can still be cultivated when improved by growing legumes and adding animal manures and commercial fertilizers, especially in cases of rather friable, clayey soils. Land, gullied so badly that even ploughing is impossible, can sometimes be advantageously used for trees, grain and legumes, such as kudzu and perennial lespedeza. Freshly exposed, highly plastic clay and raw-sand subsoil are so poor, however, that they are unprofitable for clean-tilled crops.

"For a quick method of preventing further damage and restoring the land, the U.S. Department of Agriculture has developed use of cover crops planted to tie down soil so that it cannot be blown away. A soil-conservation experimental station discovered that sumac and milk-weed, formerly just roadside weeds, were not only satisfactory anchors but can flourish on soil too poor for the usual crops. They thrive with a minimum of cultivation and even realize commercial returns—sumac leaves as a source of tannin and milk-weed pods as a substitute for kapok. Christmas holly and blueberries which can grow on poor land and have a commercial value were also found to be good protection against erosion. A good cover against erosion is the devil's shoestring plant. This poor-land plant is also a source of rotenone.

" Shelter-belt Plantings.

"For a long-term conservation and reclamation programme, one of the most effective and widely used protections against wind erosion is the shelter-belt of trees planted to serve as a wind-break and conserve soil moisture.

"A typical shelter-belt is a mile or more in length and frequently running in two directions with right-angled turns. The trees are planted in parallel rows eight to twelve feet apart with low-growing shrubs and smaller trees on the windward side so that the prevailing winds are deflected upward and over the adjoining field. The ten types of trees which are planted in each row of a ten-row shelter-belt are, depending upon climate and soil: (1) low-growing shrubs such as Russian olives, wild plum or tamarisk; (2) red cedar; (3) penderosa or Austrian pine; (4) apricot, black walnut or bur-oak trees; (5) hackberry, mulberry or catalpa; (6) green ash, black locust or American elm; (7) honey locust, ailanthus, Chinese elm or coffee trees; (8) and (9) cottonwood or Chinese elm, both of which grow rapidly; (10) osage orange or other shrubs like those in the first row. To keep cattle from destroying plantings by grazing and trampling, the belt is protected by a strong fencing.

"In areas where shelter-belts are used, a co-ordinated planting scheme has been worked out for each township with twelve parallel shelter-belts spaced a half-mile apart. Each row extends six miles across the township with some breaks for roads and bad terrain. The ideal shelter-belt pattern calls for seventy-two miles of planting in each township, but because some ground is unsuitable for trees, fifty miles of planting are considered adequate. Shelter-belt planting does not call for mile upon mile of unbroken trees and a completed shelter-belt zone consists of a series of groves, specially planted windbreaks and orchards.

"Farmers have found that in addition to breaking the sweep of incessant winds, shelter-belts have added humus to soil and humidity to dry air, lessened the danger of crop firing, provided fence-posts wherever the trees required thinning and formed sanctuaries for wild-life, particularly insect-eating birds. In northern areas, they have stopped snow drifting over cultivated fields.

"It is calculated that one acre of shelter-belt costs the United States Government less than thirty dollars and protects twenty acres or more of land. Over a fifty-year period and allowing for tree replacements, the cost to the Government for a protected acre of land will be less than four cents a year, and the cost to the farmer, mostly in labour, is less than three cents a year financially.

"Subsurface Tillage.

"Used concurrently with cover crops or with such long-term protective measures as shelter-belts, the grassing of waterways and subsurface tillage has also helped American farmers in their battle against wind erosion.

"Subsurface tillage which leaves stubble and straw on the surface undisturbed and stirs the soil from beneath was developed on the theory that a layer of crop residue acts as a protecting blotter over the land. This measure not only protects the soil from blowing away, but increases its absorption of rainfall and retards evaporation. For subsurface tillage, sweeps or blades almost flat in shape and with a spread of thirty to forty-five inches undercut the soil at a depth of three to six inches. Several sweeps may be attached to beams of lister or to tillage bars. Another implement for subsurface tillage is a straight flat blade, sixty to seventy-two inches long and held in the soil by shanks at each end. A rod weeder with shovel attachments is coming into use for lighter soils.

"In the case of corn, the land is undercut with sweeps. If one corn crop follows another, stalks from the old crop are broken with a stalk-cutter but remain on top. If weeds are a problem, the field is cultivated with sweeps at a two or three-inch depth. Because on many fields the subsurface tillage leaves the ground too loose for a good seed bed, an ordinary rotary hoe pulled backward or with teeth reversed was devised. The crop is planted right through the surface stubble by regular corn planters equipped with disc furrow openers on stub runners. In keeping down weeds in rows, the cultivator is equipped with sweeps and used with the rolling disc shield next to the row.

"For small grains or legumes, adaptations of standard equipment have been devised to get the seed beneath the stubble. For wheat, a drill is fitted with a straight disc in front of each drill row to cut through the surface. A wing on each drill keeps trash away. For alfalfa or sweet clover, a standard seeder is mounted on a reversed rotary hoe and the job of planting the seed and firming the soil is done in one operation.

"Despite millions of American acres redeemed as fertile crop-land after erosion, millions more still remain fallow, and soil-conservation experts and farmers are experimenting for new and better methods of reclamation. With soil resources recognized as the capital stock of the nation, America's fight against erosion has continued throughout the war."

Correspondence

Production-Cost Studies.

Sir,

In the article "Production Cost Studies as a Field of Research in Agricultural Economics", published in the March journal, Mr. K. O. Campbell raises by implication a very important question for students of farm economics. Amongst the diverse problems of our rural industries where should a start be made in the economic field? Cost of production studies receive so much attention, particularly from farmers, because the object is so obvious, the results so tangible. No one who has studied the literature of the past three decades on this subject can fail to be impressed, as Mr. Campbell has been, by the disappointing results that have followed optimistic claims of the benefits to be derived from such research. It might be emphasized, however, that there is a difference between attempts to discover from the intractable material of farm data the cost per unit of production on the one hand and on the other to find comparisons between the additional costs of various alternative enterprises on the farm. Both are termed production-cost studies. Perhaps, also, we should appreciate the background against which criticism was directed to the mass of cost-of-production data compiled in U.S.A. and Great Britain in the early twenties. These projects, to put it bluntly, were very much overdone and writers such as King in Great Britain and Bennett in U.S.A. crystallized the general reaction against the over-optimistic claims that were being made as to their value. In Australia, where so little has been accomplished during the past twenty years except by various Royal Commissions, it might not be altogether futile to outline the cost structure of our major industries by the survey method; particularly if such research were preceded by an adequate qualitative analysis of the areas studied.

Farmers are no less conscious of their interests than any other section of the community and their demand for cost-of-production studies has arisen from a deep-seated awareness that in the immediate past they have suffered a decisive competitive inferiority *vis-à-vis* the manufacturing and commercial world. Their surplus income (as an industry) has been insufficient to finance their own development and they have been dependent on finance, external to the industry, for mechanization, expansion and for the maintenance of the productive capacity of farms. The weakness of their control over natural conditions of production and over demand is

obvious. Considerations such as these have given rise to a demand for stability that has been canalized into a demand for higher prices, and for cost-of-production studies to show that they should be obtained. It is desirable to show the reasoning erroneous, but the maladjustments from whence such arguments arise still remain.

Economic research into rural problems will require the cooperation of the farmer and therefore will have to be related to his immediate needs. Farm prices in the past often have not covered costs such as, the depreciation of the farm due to erosion, loss of fertility due to cropping, obsolescence of machinery, the capital and working costs of fodder conservation and other contingencies. It is at this end of the cost structure of our rural industries that many of the farmer's difficulties are located and it is here that economic investigation might well throw whatever spotlight is possible.

C. H. DEFRIES,

Department of Agriculture and Stock,
Ayr, Queensland,
16th May, 1944.

Manganese-Iron Antagonism in Plants.

Sir,

Since the views of Somers and Shive⁽²⁾ on this subject are quoted by Mr. F. L. Milthorpe⁽¹⁾ in his review of mineral nutrition in the latest number of this journal, might I take the opportunity of commenting on these views here?

Somers and Shive set out to show experimentally that manganese and iron are mutually antagonistic in soya beans. Their experimental evidence is so surprising that some confirmation is needed before it can be accepted for plants in general. I am not concerned here, however, with this aspect, but rather with their theoretical explanation of how such antagonism can exist. According to Somers and Shive, manganese is antagonistic because its oxidizing potential is higher than that of iron. Their table (p. 599) claims that manganese is oxidized in a plant to the quadrivalent ion which then reacts with ferrous ion as follows:



They comment, in a masterpiece of understatement, that "the details of the exact processes are not understood".

Now if this violent oxidizing agent Mn^{++++} could exist in a plant, it would destroy not only ferrous ion but almost everything else besides. The high potential of the manganous-manganic system is a guarantee that manganic ion will *not* exist. If a plant contained some oxidizing mechanism that allowed such an improbable ion to form, such a mechanism would attack ferrous ion before it attacked bivalent manganese. This argument holds all the more strongly for cobalt, which requires a still higher potential than manganese for its oxidation. The fallacy of Somers and Shive's scheme may be seen more clearly if we invent a corresponding scheme for reduction, for example, "Potassium by virtue of its high reducing potential is able to reduce ferric compounds in plants to the ferrous state".

Manganese and cobalt might catalyse the oxidation of ferrous ion in several ways; they might, for example, catalyse the destruction of protecting organic molecules. Wherever the truth may lie, the explanation of Somers and Shive cannot be right. Fallacious applications of oxidation potentials in plant physiology are so common in recent literature that a protest is overdue.

1. Milthorpe, F. L.: J. Aust. Inst. Agric. Sci., 10: 122-128, 1944.

2. Somers, I. I., and Shive, J. W.: Plant Physiol., 17: 582-602, 1942.

G. W. LEEPER.

School of Agriculture,
University, Melbourne,
25th October, 1944.

Book Reviews

SUPPLEMENT TO STUDIES OF THE IDENTIFICATION OF TIMBERS,

by Alexander L. Howard.

(MacMillan and Co., Limited, London. 1944. Price, 5s. sterling.)

This supplement contains a further 153 photomicrographs of transverse sections of woods, including 16 Australian species. The additional studies should prove very useful to all interested in timbers, but it is regretted that the botanical name is not always available.

R. H. ANDERSON.

VEGETABLE MATTER IN THE NEW SOUTH WALES WOOL CLIP,

by E. J. Milthorpe.

(Pp. vii+60 and end-paper map. Central Wool Committee Testing House, Sydney. 1943. Price £1.)

This volume contains a series of drawings and short descriptions, each occupying a page, of the main burrs, grass and weed seeds occurring in the wool clip of New South Wales.

The volume was produced for the use of the wool trade, including growers and manufacturers. Some interesting agronomic aspects of the wool-borne weed seeds and fruits are mentioned in several places, and the distribution over the State of the plants producing the burrs, etc., are shown on an end-paper map.

PHOTOPERIODISM IN THE POTATO, by C. M. Driver and J. G. Hawkes.

(Imperial Bureau of Plant Breeding and Genetics Publication, Cambridge, 1943. Price 2s. 6d. sterling.)

The first half of this bulletin is a summary by Mr. Driver of the present-day knowledge of the effect of photoperiod on haulm and stolon growth, tuberization, flowering and fertilization and maturation of the potato. The importance of temperature on the photoperiodic response, especially in relation to breeding potatoes for tropical climates, is given due emphasis. In this connection, it appears that more attention will need to be given to heat-resisting species, rather than to short day ones. The heritable nature of photoperiodism is also discussed.

This summary is a useful contribution to the existing knowledge of the subject, since Mr. Driver has carefully analysed the available data, and has drawn some very interesting conclusions from it. In addition, he has shown that the whole subject of photoperiodic effect in the potato needs much more research before any degree of completeness can be reached in our knowledge of this reaction.

The second half of this bulletin, written by Dr. Hawkes, concerns the results he obtained in an investigation of the photoperiodic responses of some South American potatoes. The supposition is made that the photoperiodic mechanism mainly influences the dominant method of reproduction of the various plants. Thus, in potatoes, tuber production is most affected, whereas in soya beans and tobacco, seed production is most influenced.

E. M. HUTTON.

POTATO COLLECTING EXPEDITIONS IN MEXICO AND SOUTH AMERICA. II. SYSTEMATIC CLASSIFICATION OF THE COLLECTIONS, by J. G.

Hawkes.

(Imperial Bureau of Plant Breeding and Genetics Publication, Cambridge, 1943. Price 7s. 6d. sterling.)

Dr. Hawkes has given to potato agronomists, in this bulletin, a lucid and interesting rendering of a difficult and complex subject. The data presented on the tuber-forming members of the genus *Solanum* have been accumulated in part from findings recorded in the literature of the subject, and in part from the author's detailed observation of the material gathered by the Empire Potato-Collecting Expedition, of which he was a member. Dr. Hawkes has given due credit to the Russian scientists for the part they have played in initiating world-wide interest in near relatives of the cultivated potato, and also for the part they have played in classification of the important subsection *Hyperbasarthrum*. The author makes no claim to finality in his classification, and points out where weaknesses lie, and where further research is needed.

The bulk of the text concerns the description, with illustrations, of the known tuberous species of the genus *Solanum*. However, interesting discussions are given of the taxonomy, phylogeny, and cytology of potato species, as well as a section on the origin and evolution of cultivated potatoes. At the conclusion of the bulletin, a complete list of the Empire Potato Collection, and a list of the important references are given. It is a pity that the index had not been arranged alphabetically for the readers' convenience. However, this bulletin provides the first readable and accessible exposition of the intriguing subject of "wild potatoes", which species may, at the hands of the potato breeder, provide, in the future, a key to some of the problems facing this important crop.

E. M. HUTTON.

Personal Notes

Dr. H. J. Hynes was appointed Chief of the Division of Marketing and Agricultural Economics in the New South Wales Department of Agriculture in recent months. Previously he had been acting for a period in this capacity, and his recent confirmation in the position marks the first appointment of this rank in Agricultural Economics in the Commonwealth.

At the same time, Dr. C. J. Magee, who has been Acting Chief Biologist for some two years, was appointed Chief Biologist, Division of Science Services in the New South Wales Department of Agriculture.

Mr. L. T. Judd, Division of Plant Industry, New South Wales Department of Agriculture, has been appointed to the newly created position of Executive Officer of the Farm Mechanization Scheme.

Flying-Officer F. C. Henderson recently visited the New South Wales Department of Agriculture on leave from service as Meteorologist attached to forward fighter squadrons in the South-west Pacific. F./O. Henderson was formerly Agricultural Instructor in New Guinea.

Queensland members of the Institute who have been promoted during the recent months include D. O. Atherton, promoted to the rank of Major, and J. E. C. Aberdeen and H. E. Young, promoted to Captain.

D. R. L. Steindl has resumed duties with the Bureau of Sugar Experiment Stations, Brisbane, after more than two years' service at a Commonwealth explosives factory.

The following members have recently left the Victorian Department of Agriculture for other employment: Mr. L. W. Miller, who has taken the position of Entomologist in the Tasmanian Department of Agriculture; Mr. F. A. Maher, who has transferred to the Commonwealth Food Control; and Mr. R. H. N. Trembath, who, as a dairy technologist, is now with Australian Sunny South Service Pty. Ltd. Mr. L. R. Scharp, who was formerly with this company, has been appointed Production Manager of Maffra Co-operative Milk Production Co. Ltd.

Following release from the A.W.A.S., Miss Lorna Byrne has been working with the Rural Reconstruction Commission on the subject of amenities in rural life.

Mr. R. D. Croll is with Drug Houses of Australia Limited, of which Elliotts & Australian Drug Pty. Ltd. is the Sydney house, in charge of the Statistical Research Section, and is stationed at Rozelle. His work includes the examination of experimental and production data with particular regard to their agricultural applications.

Mr. M. V. O'Reilly has recently resigned from the N.S.W. Department of Agriculture and joined the Statistical Research Section at Elliotts and Australian Drug Pty. Ltd. as a Research Officer.

Mr. C. C. Crane, Chief of the Division of Information and Extension Services, N.S.W. Department of Agriculture, is at present organizing a school of instruction for extension workers. This school will last for ten days and will be held at Newport, N.S.W., in February, 1945.

Under appointment to the Commonwealth Department of External Affairs, Dr. Eric Ashby, formerly Professor of Botany, Sydney University, now holds the position of Scientific Attaché to the Australian Legation at Moscow.

